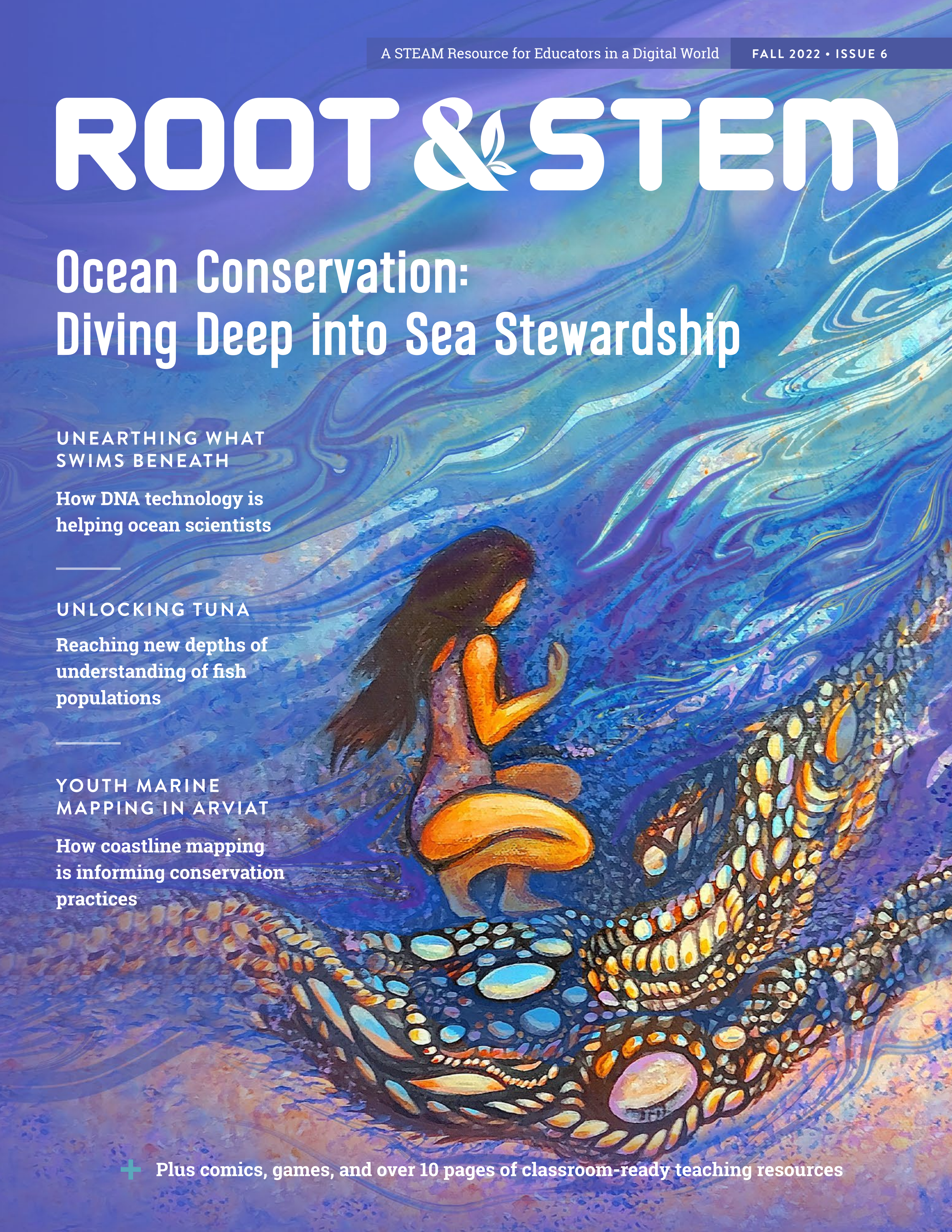
A STEAM Resource for Educators in a Digital World
FALL 2022 • ISSUE 6

ROOT & STEM



Ocean Conservation: Diving Deep into Sea Stewardship

UNEARTHING WHAT SWIMS BENEATH

How DNA technology is helping ocean scientists

UNLOCKING TUNA

Reaching new depths of understanding of fish populations

YOUTH MARINE MAPPING IN ARVIAT

How coastline mapping is informing conservation practices

+ **Plus comics, games, and over 10 pages of classroom-ready teaching resources**

PINNGUAQ
LIFE CYCLE

Pinnguaq follows a life cycle model to support the core phases of a person's learning journey in STEAM education. We strive to provide educators and students with opportunities and resources each step of the way.

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To learn more about what we do, visit our website at

pinnguaq.com

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ROOT & STEM

ABOUT PINNGUAQ

The Pinnguaq Association, a not-for-profit organization, incorporates STEAM into unique learning applications that promote storytelling, health, wellness, and growth in rural and remote communities. At its core, Pinnguaq embraces diversity and creates opportunities in order to empower all people.

DIGITAL TAXONOMY

Computer Science Education is more than just coding. A comprehensive approach to it includes learning skills and competencies from each of the areas listed below. Look for the following icons at the end of each article for suggested curriculum connections. *Reference: Learning for the Digital World: A Pan-Canadian K-12 Computer Science Education Framework. 2020. k12csframework.ca*

- CODING AND PROGRAMMING
- COMPUTING AND NETWORKS
- DATA
- TECHNOLOGY AND SOCIETY
- DESIGN

The Pinnguaq Association acknowledges the support of the Government of Canada in developing this educator resource.

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An Ocean of Us

This issue of Root & STEM *focuses on ocean conservation and the role communities play in successful and significant ocean conservation practices. In each article, we see examples of the ways in which communities and everyday citizens play a critical role in ocean conservation advocacy, data collection, and marine mapping. This issue highlights the importance of history and the various perspectives (both Indigenous and non-Indigenous) on building successful ocean conservation practices.*

COURTESY OF MARY MCDONALD

I'm honoured to write an op-ed for *Root & STEM* by Pinnguaq, an organization that started in my hometown of Pangnirtung, where I learned firsthand about conserving precious resources. My parents and elderly family members taught me to have high regard and respect for the animals we harvest for our sustenance.

I started working for the Iqaluit office of the World Wildlife Fund Canada (WWF) in an official capacity in the spring of 2018, but had had interactions with them prior to that. The organization impressed me because they wanted to work with Inuit. It is on that premise that I started my work with WWF, consulting with communities on how we can assist them in their efforts to manage limited resources here in Nunavut more effectively.

The work we have done during my short time with the WWF has been very rewarding for me personally and truly uplifting for some community members. For instance, we issued mariner's guides to shipping companies to increase their awareness of marine mammals and their migratory routes to prevent casualties.

The WWF is also working with the community of Taloyoak in their efforts to set aside Aviqtuuq (Boothia Peninsula) for the benefit of the Inuit—what a nice, original concept!—in order to care for it and ensure its protection. We look forward to the day when Aviqtuuq will become an Indigenous Protected and Conserved Area, with community members enjoying its resources for as long as they wish.

We also worked with the Mittimatalik Hunters and Trappers Organization to ensure their voices were heard during the environmental review process over Baffinland's proposed Mary River Mine expansion. We offered technical expertise and other support throughout the hearings, including funding a video presented by the Hunters and Trappers Organizations so community members who were unable to attend could still testify about the impacts of mining on ecosystems, wildlife (like the narwhal), and residents. Those Inuit who went before the board were heard and the Nunavut Impact Review Board recommended rejecting the massive expansion.

We have tried to follow up on requests for community members to meet with federal decisionmakers to ensure they are heard there, too. Sadly, the federal government, which talks endlessly about reconciliation, has refused to meet with the Inuit of Pond Inlet, who will have to live with their decision. But we will continue supporting the community of Pond Inlet in their efforts to conserve treasured resources.

We have also been travelling to communities across Nunavut, helping to make certain that their concerns and wishes are added to the Nunavut Land Use Plan. We look forward to ensuring they are included in any new plan adopted by the governments and Inuit of Nunavut.

These are just a few of the projects we have worked on, and I look forward to more progress on other fronts. Qujannamiik for asking me to explain the work of the WWF in my homeland of Nunavut.

— **PAUL OKALIK**
Lead Arctic Specialist,
World Wildlife Fund Canada

TERESA YOUNG

Cover Illustration

Teresa Young is a Métis artist, born on the West Coast of Canada. She fell in love with Nova Scotia—her life's dream of the perfect place to live—and moved there in 2010. Her art style is intrinsically Indigenous (and unique), with flowing complementary colours and bold lines. She moves between purely abstract and surreal acrylic paintings and digital art formats when expressing her style.

PAUL OKALIK

Guest Editorial: An Ocean of Us • Page 5

Paul Okalik was raised in Pangnirtung and attended the Federal Day School, where he was not allowed to speak Inuktitut—the only language he knew at the time. At the urging of his late mother, he attended Carleton University to study Canadian Studies and Political Science, and the University of Ottawa, to study Law. After becoming a lawyer, he was elected to the first Nunavut Government for two terms. He currently works as the Arctic Specialist with the World Wildlife Fund in Iqaluit.

SOFIA OSBORNE

Searching for Sea Stars • Page 7

Sofia Osborne is a writer, reporter, and audio producer based in Vancouver. Her environmental journalism has appeared in *The Tyee* and *The Narwhal*, and she is the co-host and producer of *Beyond Blathers*, an Animal Crossing science podcast.

SHIRLEY TAGALIK

Youth Marine Mapping in Arviat • Page 9

Shirley Tagalik is a director at the Arviat Aqqiumavvik Society, where she researches areas of education, child and language development, youth engagement, climate change, and more. Working with Inuit Elders for over 30 years, she documents Inuit cultural knowledge and finds ways to revitalize that knowledge in community programs.

KANDICE CROSS

How to Use a GPS Device • Page 13

Kandice Cross has been a Secondary School teacher in the Greater Toronto Area for the last 16 years. She is committed to helping students develop a profound connection to the world around them in an engaging and meaningful way.

CAROLANNE BLACK

Conserving Local Knowledge • Page 11
Sustainable Fishing for 700 Generations • Page 17

CarolAnne Black tells ocean stories. She writes on all topics related to the ocean, and especially loves to work on writing projects that help empower girls and women in ocean science. You can see more about her at **carolanneblack.com**. She likes to swim with her three kids and talk about how the water is making its way back to the ocean.

KEVIN FRANK

Swimming in Plastic • Page 18

Kevin Frank is an award-winning author and illustrator and the creator of the popular *Scurvy Dogs* graphic novel series for children. He lives in rural Ontario and steals his best material from his wife and three children.

ALANA MCCARTHY

Look and "Sea" • Page 24

Alana McCarthy is an illustrator from Toronto who makes bright, painterly, eye-catching imagery, lettering, design, and murals. Over her award-winning 20-year career, she has worked with amazing clients like Disney/Pixar, Nickelodeon, *The Wall Street Journal*, Coca-Cola, Scholastic, and Penguin Books.

JESSICA LEEDER

Unearthing What Swims Beneath • Page 26

Jessica Leeder is an Emmy Award-winning independent journalist who writes fiction and narrative non-fiction. Her work has appeared lately in *The Walrus*, *MaRS Magazine*, *Chatelaine*, and *The Globe and Mail*, where she served as the national newspaper's Atlantic Bureau Chief.

KAREN PINCHIN

Unlocking Tuna • Page 32

Karen Pinchin is a Kjipuktuk/Halifax-based investigative journalist who writes about food systems and the environment. Her first book, a narrative non-fiction exploration of Atlantic bluefin tuna, will be published in 2023. She is on Twitter at @karenpinchin.

Searching for Sea Stars

BY SOFIA OSBORNE

On a rainy day in May, 55 Saturna Island residents took to the intertidal zone in search of sea stars. With rulers and guidebooks in hand, they noted the size, colour, and species of stars, all in the hope that their observations might help researchers protect these iconic marine creatures, and determine the cause of the mysterious sea star wasting syndrome (SSWS) that has decimated populations up and down the west coast of North America.


PHOTOS COURTESY OF ROBYN QUAINTANCE

Previous page: An ochre sea star (Pisaster ochraceus) shown with its characteristic short arms and an array of white spines. Top: Two ochre stars (Pisaster ochraceus)

This was the second annual Sea Star BioBlitz held in Saturna, the southernmost of British Columbia's Gulf Islands. The BioBlitz is a citizen science event organized by local sea star enthusiast Robyn Quaintance, who saw the effects of SSWS firsthand on her daily kayak trips and wanted to do something to help.

"It was really sad, and kind of ugly," she recalls. "You could see some of them would lose one or two of their legs, and that they were wasting away."

While SSWS is not a new disease, the current wave has been devastating, causing what scientists say is the largest disease epidemic ever observed in wild marine animals. The sunflower sea star, which can have as many as 24 arms, was particularly affected, and its decline has had major repercussions for the kelp forest ecosystems where it serves as an important predator.

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Melissa Miner, a researcher at UC Santa Cruz, has been helping monitor sea stars with the Multi-Agency Rocky Intertidal Network (MARINe), a consortium of organizations along the west coast of the United States. It was one of MARINe's partner organizations, Olympia National Park, that first observed sea stars with wasting disease in 2013. Within months, other MARINe groups were finding diseased stars as well.

"When we started to see the disease kind of ramp up, we were getting a lot of requests and concern from the general public, and a lot of people reaching out wondering how they could help," she says. "We realized that we could train people to identify sea stars and use the same methods that we use to track those long-term trends in sea star populations."

Now, Miner estimates there are 15 to 20 long-term monitoring sites operated by citizen scientists who have been trained by researchers from MARINe. She cautions that this is a big commitment, and that for a simpler way to contribute, anyone is welcome to submit observation data to the MARINe website. That data will be added to their sea star tracking map, which helps alert researchers to where the disease is being seen.

"We researchers within the marine group, we are experts in species identification ... but we are not experts for every single place along the west coast. Those are the people who are there every day; they're the ones who are going to notice if something seems different," Miner says. "And so that's been really valuable to have that collaboration with various groups and individuals who really have that amazing local knowledge."

While there are hypotheses about what might cause SSWS, scientists still don't have an answer, Miner explains. Data from the sea star tracking map is being used to test possible correlations between SSWS and factors like sea surface temperature, shipping traffic, and distance to the nearest large population centre. So far, according to Miner, nothing has correlated nicely with the patterns on the map.

Data from the first Saturna sea star BioBlitz was compiled by local high school students and sent to MARINe. They plan to do the same with this year's data. As a retired teacher, Quaintance believes getting students—and everyone else—involved in citizen science is vital.

"I don't think that we, as a society, can properly fund as many scientists as we need to, because there's so much going on," she said. "I really think it's important for us as just regular citizens to try to help get the information out there of how many sea stars we have." &

To get involved, visit **simres.ca** for more information on the next Sea Star BioBlitz and other marine research projects conducted on Saturna Island.

TECHNOLOGY AND SOCIETY

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PHOTOS COURTESY OF AQQIUMAVVIK SOCIETY

An M2Ocean HydroBlock device for oceanographic monitoring

Youth Marine Mapping in Arviat

BY SHIRLEY TAGALIK

The Aqqiumavvik Society is a community alliance of public, mental, and community health groups in Arviat, Nunavut. Aqqiumavvik practises a community-identified approach, ensuring that any program or service we develop is based on needs that have been identified by the community itself.

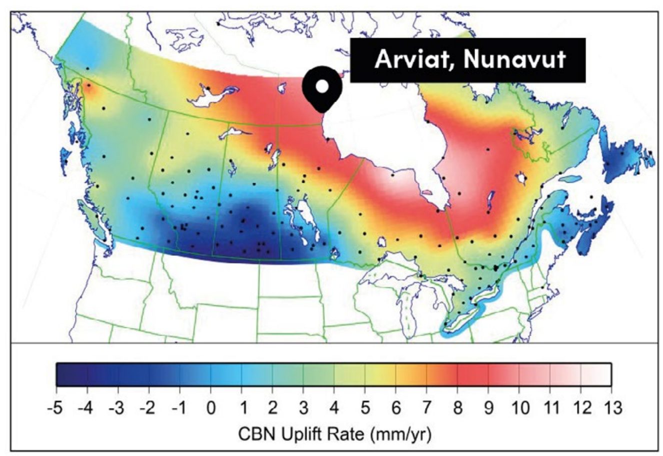
As such, the Aqqiumavvik Ujjiqsuiniq Young Hunters Program was born. The program is meant to teach youth aged 8 to 18 about sustainable harvesting practices. For years, it has also been monitoring decreasing annual precipitation due to climate change. The decrease in snow accumulation in particular contributes to changes in seawater coverage in coastal zones. These rapidly changing conditions and the concerns identified by the community in the Arctic Corridors Research has led Aqqiumavvik to look for solutions to address safer marine travel. How best might we go about mapping coastal waters?

The Arviat community joined the Arctic Corridors Research Project in 2017. The project engaged with 14 northern communities to map and investigate existing shipping routes and their impacts on wildlife, coastlines, and lifestyles, as well as to consider recommended alternative routes for increased shipping around these communities. In Arviat, a group of youth, community researchers, Elders, and experts in land and marine travel participated in the work, which led to a community report. The report outlined a series of recommendations prioritized by the community to address impacts of increased shipping on the community. The primary finding was that accurate marine maps are essential to ensuring safe marine travel. Although approaches to the community were mapped in 1997, no mapping of the coastline has taken place.

Marine mapping is critical to the Arviat area because Hudson Bay is one of the areas in the world most impacted by isostatic glacial rebound—the lifting up of land depressed by the weight of glaciers. The greater the weight of the glacier, the greater the rebound effect after the glaciers melt.

Glacier ice in Hudson Bay was some of the last to melt. In Arviat, the evidence of post-glacial rebound is evident along the coast, where shoals, reefs, and even small islands are visible today, whereas there was water coverage as little as 10 years ago.

This map shows the rates of lift occurring across Canada. As indicated, the seabed around Arviat is lifting at a rate of about 10 millimetres per year.



Map Source: earthscience.stackexchange.com/questions/4728/why-is-relative-sea-level-falling-in-hudson-bay

The Canadian Hydrographic Service did not have plans to conduct marine mapping within Arviat since it is not a high shipping area. The Aqqiumavvik Society looked for technology that could enable us to produce our own bathymetric surveys. This led us to the Interdisciplinary Development Centre for Ocean Mapping (CIDCO)—a marine geomatics and hydrospatial research and development organization that develops technologies for marine mapping. CIDCO shared information about a product called HydroBall that we could use in Arviat. They also introduced us to M2Oceans, an organization that was able to provide us with the technology we needed.

PHOTOS COURTESY OF AQQIUMAVVIK SOCIETY

Members of the Aqqiumavvik Society out at sea

In 2019, CIDCO provided us with training to set up and use the HydroBall technology. M2Oceans provided us with the equipment during that survey year. We found that the HydroBall technology was not well suited to our conditions and that we were very limited in the number of days we could survey successfully, since the technology required very calm waters. At the end of the season, we were able to participate in a presentation to a bathymetry and hydrography conference on this work.

In 2020, we piloted the HydroBlock system, which was much better suited to our conditions and, with training in the technology, we were quite successful in generating accurate maps for our area. We are interested in securing a second HydroBlock so two boats can be in operation over our short boating season, but our attempts to secure funding for this have not yet succeeded. The purchase of and training for the technology requires an outlay of about $30,000. (The data from our 2021 survey was presented at the International Map the Gaps Symposium 2021 Redux.)

Our 2022 mapping season is just opening. We are still operating with just one HydroBlock and boat, but hope to complete the map of our local harbour. We will also try to map the area around Nuvuk (or Eskimo Point), which is where ships currently anchor with supplies for the community. The Government of Nunavut (GN) is relocating the fuel resupply zone to a new area along this coastline but, with no maps or charts available, and with little research on the predictions and impacts of glacial rebound, the community has concerns for the plans currently in place. We hope to be able to provide information to the GN before they commit to this new installation.

It is important to note that it is the community's youth who are being trained in the use of this technology and in the development of marine maps. Maps are available on our Facebook page and hard copies are available in the community. We are also making them available through SIKU (**siku.org**), a mobile app and web platform that provides tools and services for ice safety, language preservation, and weather. It is expected that our youth-made maps will also become available through the Canadian Hydrographic Services website. In the meantime, local hunters are happy to know where they can travel safely in our increasingly changing waters. &

Glossary

Isostatic Glacial Rebound—The rise of land that was previously weighed down by huge masses of glacial ice

Hydrography—The science behind measuring and noting physical aspects of bodies of water and the surrounding land

Bathymetric Survey—A method of measuring the depth of bodies of water

Additional Links

Arctic Corridors Research Project in 2017:
arcticcorridors.ca

Arctic Corridors and Northern Voices Community Report:
arcticcorridors.ca/2019/12/13/arviat-nu-community-report

Earth Science Stack Exchange Map of Hudson Bay Sea Level Rates: earthscience.stackexchange.com/questions/4728/why-is-relative-sea-level-falling-in-hudson-bay

Interdisciplinary Development Centre for Ocean Mapping (CIDCO): cidco.ca

CIDCO 2021 Colloquium Conference Presentation:
youtu.be/fRtY5Ks5BPI

International Map the Gaps Symposium 2021 Redux Presentation: youtu.be/_tgWFG5Ua6A

Aqqiumavvik Society Facebook Page:
facebook.com/Aqqiumavvik

SIKU: The Indigenous Social Media App:
pinnguaq.com/stories/siku-the-indigenous-social-media-app/

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Conserving Local Knowledge of Labrador's Lake Trout

BY CAROLANNE BLACK

Alex Flynn grew up fishing for lake trout with his dad through a hole cut in the ice. Out on the lake, he was supposed to be jigging—bobbing his fishing line up and down to entice the trout to bite. But Flynn, a member of NunatuKavut and of settler ancestry, spent much of his time as a child lying on the ice, peering down the hole hoping to see a trout bite the hook. It was a terrible way to catch fish, Flynn notes, and a great way to get cold and wet. At the end of the day, Flynn and his dad would bring their catch to his grandparents' house. His grandmother would prepare the fish for dinner and visitors to the house would go home with gifts of trout.

Flynn has since left Forteau, the 400-person fishing community he grew up in on the South Coast of Labrador. Now a master's student at Memorial University in St. John's, he brought his fishing knowledge forward when he joined a team studying lake trout populations in Labrador: "It's what I grew up with; it was related to my home."

For his studies, Flynn began reviewing previous research on lake trout. He noticed that most of what had been written about lake trout came from regions outside Labrador. Most strikingly for Flynn, the knowledge he had grown up with was absent.

Lake trout are widespread across North America, but Labrador's populations live in a different environment and climate than others. The climate in Labrador is relatively cold and, most significantly, Labrador's waterways are made up of a vast system of small, shallow lakes connected by rivers and streams. Flynn says Labrador's landscape "creates more isolation and makes little pockets of [trout] populations." This, Flynn explains, is different from large lakes, where fish populations interact continuously and so generate more genetic diversity. And more genetic diversity means the populations can be more resilient to climate change. To understand Labrador's lake trout better, and to be able to support their conservation, we need to know not just about lake trout in general, but what is particular to Labrador's populations.

Flynn and the team of researchers set out to determine if the fish were moving among the lakes. They sequenced the DNA of 559 trout samples donated from fishers from 35 lakes. Since interacting populations have closer DNA structures, Flynn says with their data, "you can see which populations are more similar or different." The results can help answer questions like: Where are fish travelling? Are they travel-

Left: Alex out on the ice. Right: Alex's dad holding his catch ling upstream or downstream? What are the barriers for trout moving among lakes? Are barriers caused by people, climate change, or nature (e.g. a waterfall may limit travel to one direction)?

Throughout his project, Flynn was working to increase our knowledge of the lake trout particular to Labrador; but he still felt like the accepted methodology of science meant the knowledge he had grown up with couldn't be included. All that changed, however, in early 2020, when he became a lab technician at Memorial University's Civic Laboratory for Environmental Action Research (CLEAR) (**civiclaboratory.nl**).

CLEAR is an anti-colonial feminist lab situated on the ancestral homelands of the Beothuk. Its website states, "Our methods foreground values of humility, equity, and good land relations. We're working to do research differently." CLEAR's work focuses on the environmental monitoring of plastic pollution. CLEAR researchers survey beaches, skim surface water, and analyze bird and fish guts, searching for plastics. The results tell us what types of plastics and how much are getting into the environment and into animals' digestive tracts.

Flynn says that if something doesn't fit within the values of CLEAR, they find another way. Max Liboiron, the director at CLEAR, describes those values as being baked into everything CLEAR does, from taking out the trash to deciding who is named as first author on a paper (which can affect an academic career).

The team at CLEAR maintains good land relations in several ways, which includes how they work with communities. Liboiron says, "CLEAR begins a relationship with a community by co-creating research questions. It then has the community hire co-researchers, who are paid by CLEAR and who bring their own knowledge and expertise." The lab will only publish data if the community consents. CLEAR also has samples analyzed by someone from those lands. In Flynn's case, he handles samples provided by Inuit communities that are part of projects sponsored by the NunatuKavut Community Council, because he is from the lands where the samples were collected.

To make research more equitable, CLEAR develops measurement instruments that can be built in a garage. BabyLegs, for example, skims surface water to collect small particles and is made of baby tights, pop bottles, and other easy-to-find materials. Liboiron says that developing technology, like BabyLegs, "means all sorts of people can do monitoring who couldn't before."

Now, Flynn is bringing CLEAR's principles into his research on Labrador's lake trout. "Working with CLEAR made me want to highlight more non-standard forms of knowledge. I want to use more local and community sources of information. When I talk to my dad, to my grandparents, to anyone from down home, they tell you how important it is."

Flynn knew there was knowledge missing from the picture of lake trout in Labrador because he could see the gap. Ensuring that any research conducted includes community members from the research location benefits not only the results but what we can learn moving forward. **&**

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To learn more about CLEAR's research methods, check out the following videos.

- **GUTS** (**youtu.be/ETnPiGNXw34**) – A short documentary film following Max Liboiron and CLEAR through their methods of practising science
- **Laboratory Life Episode 1:** Author Order (**youtu.be/ZrLOGokqL7w**)
- **Laboratory Life Episode 2:** How We Choose Our Values (**youtu.be/YYjfWZyAoh4**)
- **Laboratory Life Episode 3:** How We Run a Lab Meeting (**youtu.be/emHbn9VMKBU**)

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Left: BabyLegs device shown by the front. Right: BabyLegs in use in the water


COURTESY OF DR. MAX LIBOIRON


COURTESY OF MEOPAR

How to Use a GPS Device

BY KANDICE CROSS

Most of us have heard of Global Positioning System (GPS) technology and have come to rely on it to get us from point A to point B. The use of GPS technology extends well beyond giving users basic directions. For example, GPS tags have long been employed to tag and track a variety of fish and sea reptiles, which helps scientists learn more about species-specific movement and habits. By collecting this data, scientists can better advocate for management strategies that will improve conservation efforts.

What is GPS Anyway?

GPS began as a way for the United States Navy to track submarines and quickly became well-integrated within broader society. The technology has been used for everything from helping farmers with high-yield crop development and pest management to supporting wildlife management agencies in developing more accurate species protection practices. GPS has also become an integral component in transportation management systems, which have sought to increase dependability and efficiency. In addition, emergency response and natural disaster management organizations have come to rely heavily on the use of GPS—not only to aid in the delivery of essential medical support but also to use GPS data to increase the accuracy when predicting the occurrence of natural disasters.

Today, GPS is a collection of 30 satellites that orbit Earth. At any given moment, there are at least three satellites, often more, in the sky directly overhead. When using a GPS receiver, which can be a handheld GPS device or a smartphone app, we can use these satellites to help us determine our precise location, using latitude and longitude coordinates, anywhere on Earth's surface.

What's more, GPS devices have grown in popularity for use in recreational activities. Geocaching, for example, gives participants a chance to experience the thrill of a modern-day treasure hunt. Thanks to the immensely popular game *Pokémon GO*, the use of GPS to track and find digital prizes or locations has provided users with new fun and interactive ways to use the technology.

GPS and the Classroom

An obvious connection between GPS and the classroom might be to create a stand-alone lesson involving navigation using latitude and longitude coordinates. However, GPS can also easily be integrated into other lessons, with applications not only in geography classrooms, but also in the sciences, the social sciences, mathematics, and beyond.

By using a GPS device, students are able to mark and track their geographical locations. However, by merging this information with other data collected in the field—like ecology, urban planning, or statistics—students can make first-hand connections with the data that they have cultivated.

No GPS Device? No Problem!

In the early days, to make use of GPS, a user would require an often costly receiver. While these devices have come down in price considerably, having 30 devices readily available for student use might still prove challenging. Enter the GPS smartphone app! These days, most classrooms will have several students who have access to a smartphone and, therefore, the opportunity to turn their phones into their very own GPS receiver. Currently, there are a plethora of GPS receiver apps available. If you are looking for a free, user-friendly program, Gaia GPS: Mobile Trail Maps is a great spot to start.

Getting Started: How to Use a GPS Device

The following is a list of steps that show how to download a GPS app to a smartphone in order to use a smartphone as a GPS device.

- **STEP ONE →** Download the Gaia GPS: Mobile Trail Maps app to your mobile device. The app is free from Apple's App Store and Google Play.
- **STEP TWO →** Once you open the app on your mobile device, the app will guide you through a list of preferences to help personalize your experience. For example, the app prompts the user to consider what they like to do outdoors. For the purpose of this activity, we recommend you select "Walking" from the list of activity choices (for example, users can choose "Hiking, Trail Running, or Backpacking"). Each choice you select will help customize the app experience. It also asks permission to access your precise location and select your preferred map layers view. The app will also prompt you to create an account. This is helpful to keep track of your journeys for future reference and is completely free.
- **STEP THREE →** Your screen will now display a map with a large orange arrow representing your current location. To navigate to your first location, tap on the "+" icon located at the top right of the screen. Select "Add Waypoint" from the list of options.
- **STEP FOUR →** From here, enter the latitude and longitude coordinates of your destination. To add a waypoint, tap directly on the map. You must select two waypoints to create a "Route". You may also wish to give your location an appropriate title, for example "My First Waypoint" or "Home." Finish by tapping "Save" in the top right corner. When you tap on the screen, a prompt will appear that allows you to either "Name Waypoint" or "Delete Route Point".
- **STEP FIVE →** You will now return to the map home screen, only this time you should see a red pin indicating your marked waypoint on the map. By tapping on the red pin, you will see a screen pop up at the bottom of your map. Here, tap on the "More" button.
- **STEP SIX →** A pop-up menu will now appear. From here, select "Guide Me". A black information bar will appear at the top of your map showing you the distance in metres to the waypoint and the direction in which you are heading.
- **STEP SEVEN →** Start walking! &

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For a full list of sources used in this article, please visit pinnguaq.com/stories/how-to-use-gps-device.

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Benefits of Using GPS in the Classroom

GIVE STUDENTS A HEAD START

GPS is widely integrated in technology in society. Helping students become familiar with the basics of GPS can give them an understanding for all the ways it is integrated into our society through widely used devices (such as a smartphone).

STEM IN THE CLASSROOM

Looking for a meaningful way to integrate STEM (Science, Technology, Engineering, and Mathematics) into any classroom? With a little bit of creativity, GPS can be used to suit the needs of any subject, not just traditional STEM subject areas. For example, students might write a story set within their community. They can then record the locations of the most important events in the story and use them to create an accompanying map.

GET STUDENTS OUTDOORS

Sometimes, the best lessons happen outside the classroom. Regardless of the season, a GPS lesson provides the chance for students to get outside, build teamwork skills, and most importantly, have fun!

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GPS Lessons and Resources

Ready to get started with GPS in the classroom? Check out these resources!

- **Introduction to GPS and GPS Devices** (pinnguaq.com/learn/courses/introduction-to-gps-devices) – This lesson introduces students to the basic concepts of GPS, followed by guiding students through a fun scavenger hunt while learning to use a GPS device in the field
- **Teaching Directions, Maps, and Coordinates** (edutopia.org/naturemapping-lesson-maps-directions-coordinates) – This is a great introductory lesson that can be geared towards students of younger ages
- **Making Art with GPS** (teachengineering.org/activities/view/cub_navigation_lesson09_activity2) – This lesson takes GPS to the next level by having students create their own works of art using GPS technology
- **10 Ready-to-Go GPS Lessons** (sciencespot.net/Pages/classgpslsn.html) – These 10 ready-to-go GPS lessons include a "Hide and Seek" activity and an "Amazing Race" challenge!

Left: Ocean Wise Ocean Bridge Great Lakes 2019 Group Shot. Right: Ocean Bridge 2018 Cohort in Haida Gwaii on the Remote Learning Journey

Think Blue, Go Green

Bringing STEM to Ocean Conservation

BY THE OCEAN WISE TEAM

Marine conservation efforts have been growing rapidly in North America over the past decade. In Canada, the commitment to protect the country's land and oceans has risen from a goal of 10 per cent in 2020 to 30 per cent by 2030. Through collaborative efforts with Indigenous communities across Canada, the hope is to ensure protection for marine and coastal areas, fight the effects of climate change, and provide alternative, sustainable forms of engaging with ocean ecosystems.

Ocean Wise is on a similar mission to ensure that our oceans are healthy and flourishing. Focused on education, research, and direct-action conservation, we equip and inspire youth, citizens, businesses, and governments to empower communities and individuals to take action. Ocean Wise offers active support through initiatives like the Ocean Wise Shoreline Cleanup, which helps individuals participate in local shoreline cleanup events, and the Ocean Wise Seafood Program, which enables consumers and businesses to choose sustainable seafood options.

Ocean Wise also offers educational programming on climate change and ocean conservation for children and youth. This includes the mobile Ocean Wise Sea Dome, virtual interactive workshops on ocean conservation, and free education kits and ocean literacy courses. We know we can meet the challenges facing the ocean head on, but we need thousands of people world-wide working together.

Ocean Wise Youth

One of the key ways Ocean Wise engages Canadians and tackles ocean conservation is through our youth programs. Ocean Wise Youth brings together three hands-on leadership programs: Ocean Bridge, Direct Action, and YouthToSea. These programs provide direct experience in ocean conservation through the lens of community service. Learning from experts in marine conservation, and supported by Ocean Wise, youth are empowered to become impactful ambassadors for the ocean.

The Ocean Bridge program alone brings together 140 people (aged 18 to 30) from all over Canada to learn new skills, make a difference to ocean conservation, and connect with like-minded individuals. Learning from experts through an online platform and in-person learning journeys, ambassadors are empowered to develop service projects related to ocean health and ocean literacy in communities across the country.

THINK BLUE, GO GREEN

PHOTOS COURTESY OF OCEAN WISE

Top: Frankie Marquez on the Alumni Sailing Journey across the Salish Sea. Bottom: Marquez at Ocean Wise Shoreline Cleanup

Meet One of Our Alum

Frankie Marquez, a 2019 Ocean Bridge alum, has always been passionate about the ocean. As she grew older, she learned about the different threats the ocean faced, including global warming, pollution, overfishing, and the loss of sea ice. "This endless list of threats made me feel small, lost, anxious, and a little angry. I wanted to take action and to feel I was doing something to help the oceans that I love so much." That's when a mentor sent Frankie Marquez an application to Ocean Bridge.

Frankie Marquez loved her Ocean Bridge experience so much that she eventually wanted to be involved full-time. She now works for the Ocean Bridge team as the Alumni Engagement Manager. She believes in the program and the Ocean Bridge community and decided to get involved in sharing the experience with others.

"The fight against climate change is long, exhausting, and difficult. My advice to any environmentalist finding it difficult to stay motivated is to collaborate and surround yourself with like-minded peers."

This ocean conservation issue of Root & STEM *came about as a result of the development of a scholarship in honour of Danielle Moore, an Ocean Wise Youth alum who also spent time at Pinnguaq's Makerspace in Iqaluit. Among her many contributions, Danielle Moore held a space during the Ocean Bridge learning journey in Haida Gwaii for her cohort to safely discuss challenges and opportunities around sustainability and privilege, opening the minds of her peers to new ways of experiencing the world. She was also a leader in her local community, and organized a Conservation 101 field trip for underserved youth. She volunteered for ocean education programs and in classrooms across the prairies, organized two educational programs for an immersive service expedition in Vancouver, was a key member of the "Ocean Literacy through an Indigenous Lens" project, and led a very successful coding camp for 25 children and their parents.* &

The Danielle Moore Scholarship was named in honour of Danielle Moore, an Ocean Wise Youth alum

TECHNOLOGY AND SOCIETY   DATA

Do you know someone between the ages of 18 and 30 who is passionate about the ocean and marine life? Apply to Ocean Bridge at **ocean.org.**

Haíłzaqv community members fishing and casting a net to catch herring in Wágḷísḷa (Haíłzaqv Nation, Bella Bella, British Columbia)

Sustainable Fishing for 700 Generations

BY CAROLANNE BLACK FOR OCEAN SCHOOL

PHOTO COURTESY OF OCEAN SCHOOL

"Salmon are super-important because they come back every year to nourish us," says Desiree Lawson of the Haíłzaqv Nation. For thousands of years, the Haíłzaqv have been harvesting salmon and other food from the waters of the Pacific Central Coast. They consider it their responsibility to manage their land and ocean resources so that the next 10,000 years, or 700 generations, can continue to do the same: "We have a responsibility as people to take care of the ocean, and the lakes, and the rivers, to ensure the salmon have something to come back to."

And it's not just salmon that come back to nourish the Haíłzaqv each year. A cultural keynote species and staple food of the Haíłzaqv is herring, a small fish that migrates in schools by the millions to the Pacific Coast each spring to spawn (lay their eggs). The Haíłzaqv of Bella Bella, a coastal community on Campbell Island, British Columbia, have been harvesting herring roe (eggs) in a sustainable way for generations.

The Haíłzaqv run a commercial roe fishery for subsistence and export. To harvest the roe, the Haíłzaqv people first harvest kelp. They set the blades (similar to leaves) in lines, held in place by weights, in the protected areas of the bays and inlets preferred by the fish. Within just a few days, the female herring lay eggs upon eggs in layers on the rocks and vegetation, including the lines of kelp, covering the broad blades completely in small white spheres, which the Haíłzaqv then harvest.

Boris Worm is a scientific director at Ocean School, a free, innovative, online ocean education resource for students aged 11 to 17, developed by the Ocean Frontier Institute and the National Film Board of Canada. He says of the Haíłzaqv roe harvest that, unlike the industrial fisheries that catch herring and take the roe from the bellies of the females, "the advantage of this fishery is that it doesn't kill the herring. The herring lives on to spawn for many more years." And since each female can lay up to 18,000 eggs each year, allowing them to return to the coast in future years makes a big difference to the number of eggs that are laid and the eggs that are hatched.

The fishery brings food and jobs to the Haíłzaqv community, as well as a sense of identity to the Haíłzaqv Nation. Louisa Housty-Jones is a Haíłzaqv Tribal Councillor, roe-on-kelp captain, and traditional knowledge holder, who works to pass on the knowledge of her people's harvesting practices to the next generation. She says of the fishery: "I grew up on the water, harvesting. It's a huge part of my life. It's a huge part of my identity, of who I am as a Haíłzaqv person."

In 2020, Ocean School—a resource built by educators for educators—partnered with the Haíłzaqv Nation to tell stories of their relationship with the ocean. Through the voice of Jordan Wilson, a youth host and Haíłzaqv Coastal Guardian Watchman, the learning module presents Haíłzaqv fishing and cultural practices under the tagline: *How can we take a little and leave a lot for nature?* Wilson says of the Haíłzaqv Nation managing ocean resources: "It's our duty to protect this place so we can keep enjoying these things, to keep enjoying this place we call home. It's rooted in our DNA. It runs through our blood; it's who we are."

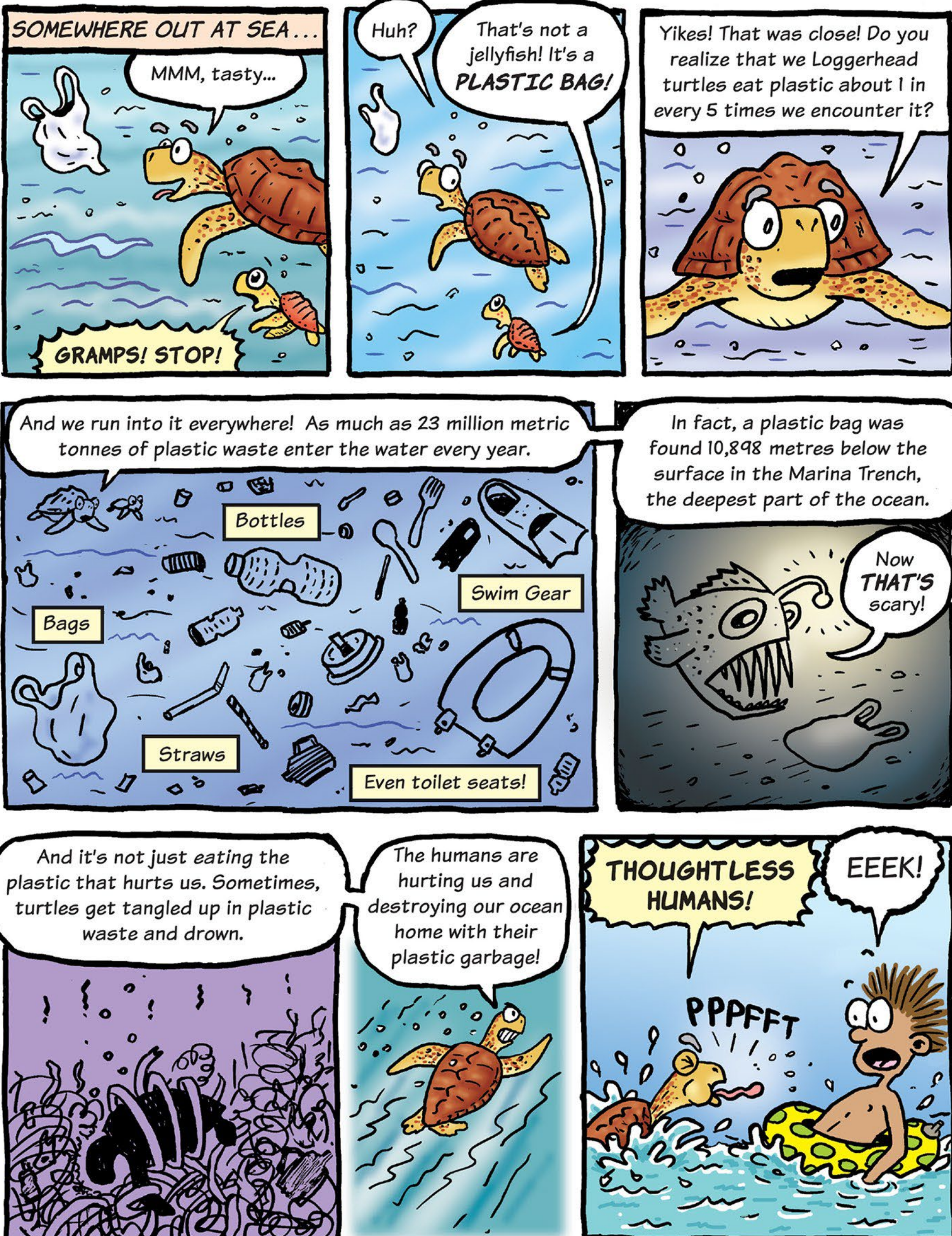
Ocean School's mission is to help us understand our influence on the ocean and its influence on us. Through an inquiry-based learning approach, Ocean School aims to empower youth with knowledge, tools, and inspiration so they can take action for the ocean. The website is searchable, accessible to hearing and visually-impaired students, and available on mobile devices. With resources that span sciences, social studies, language arts, and other subjects, each educational aid comes with a ready-made activity designed to engage students' skills in problem solving and critical thinking.

Let Ocean School take you on a deep dive into learning about harvesting herring roe, salmon, and more with the Haíłzaqv people. Learn more by visiting oceanschool.ca. &

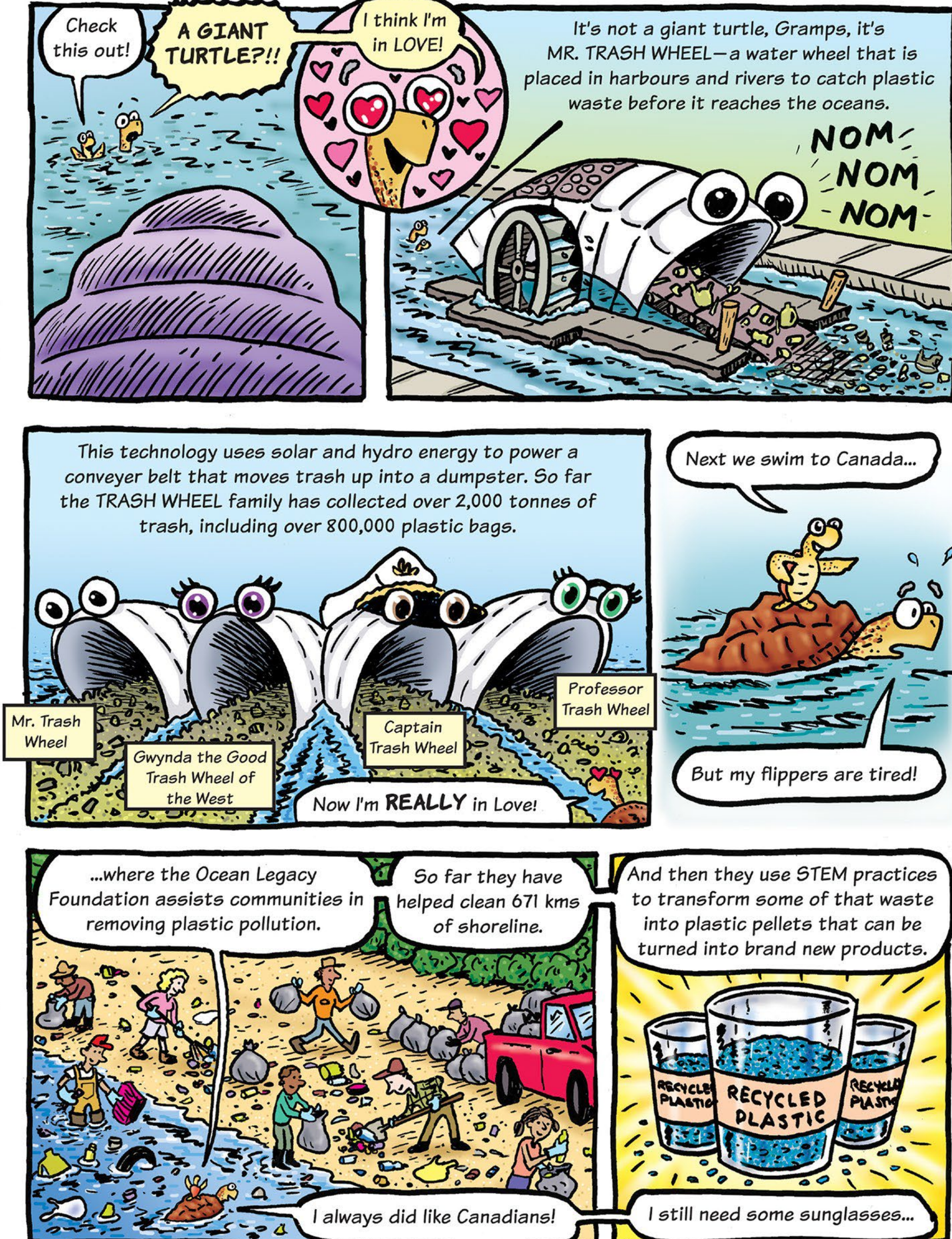
TECHNOLOGY AND SOCIETY

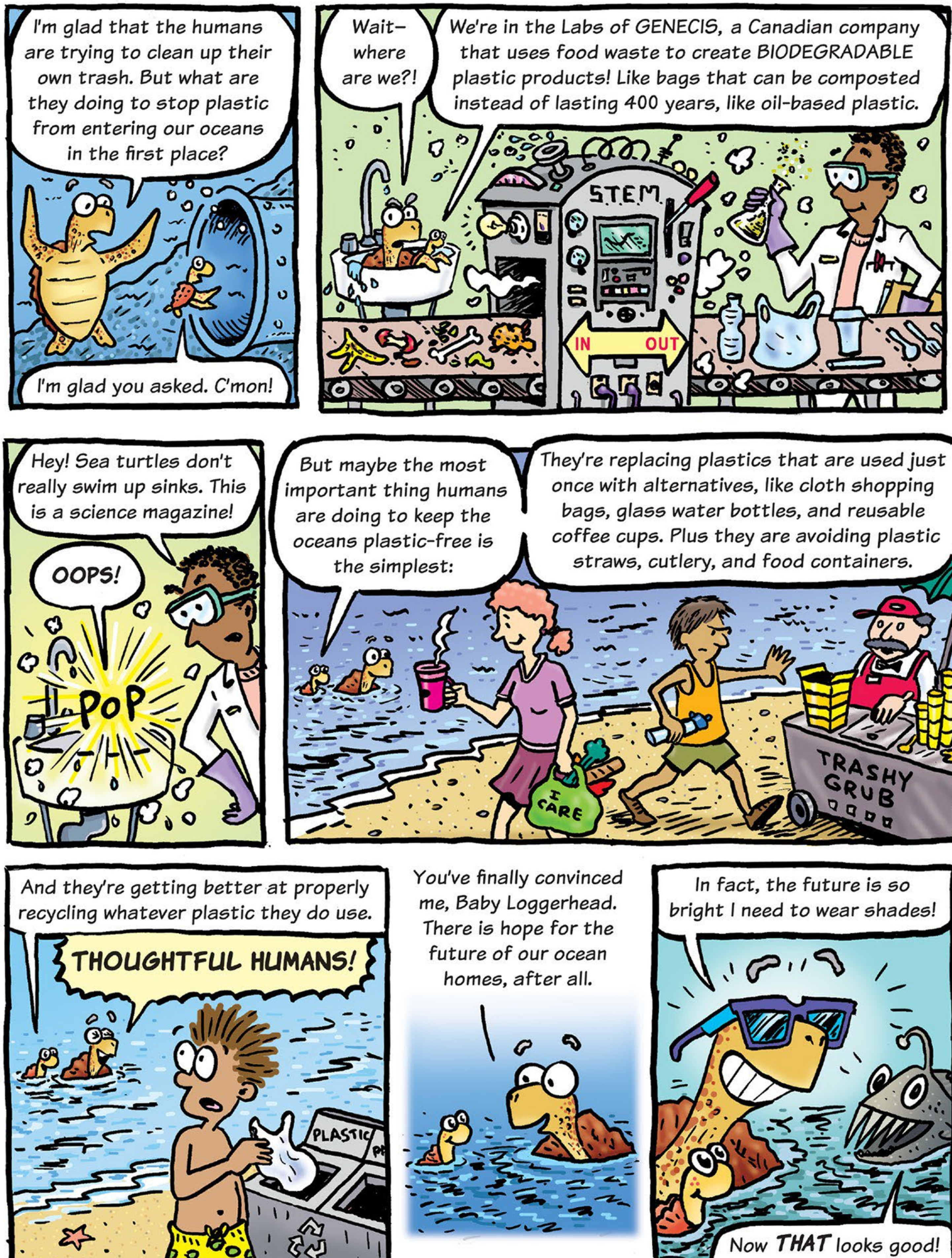
SWIMMING IN PLASTIC

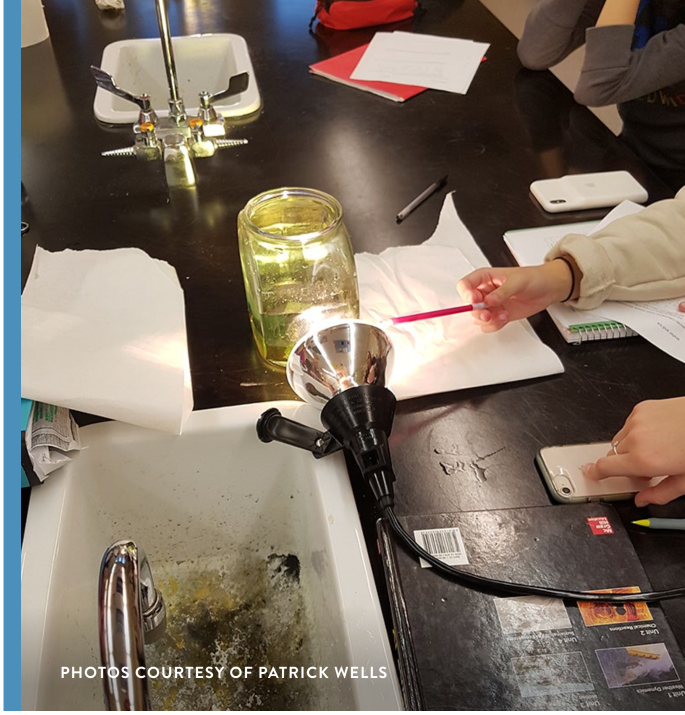
BY KEVIN FRANK




That's all true, Grampa Loggerhead, but there is good news, too! The humans are starting to fix some of these problems...
That THEY caused!
...by using science and technology to clean up our oceans and waterways.
C'mon, I'll show you.
Whoa, not so fast! I'm OLD remember?
LOOK!
What is that?
It's the OCEAN CLEANUP project!
These clever humans are using a giant net to capture plastic floating in the Great Pacific Garbage Patch.
NETS?! Turtles can get caught in nets!
True, but these nets are open at the bottom so fish and sea creatures, like us turtles, can swim right out.
WHEW!
Then, after the humans scoop out the plastic, they take it away to be recycled.
They even made sunglasses from recycled ocean plastic to raise funds to clean up 500,000 football fields' worth of ocean!
Ooooh, I wonder how I'd look with shades?
I guess some humans DO care about our planet...
And they're not the only ones. Follow me!
Wait! I didn't get my sunglasses--


Check this out!
A GIANT TURTLE?!!
I think I'm in LOVE!
It's not a giant turtle, Gramps, it's MR. TRASH WHEEL—a water wheel that is placed in harbours and rivers to catch plastic waste before it reaches the oceans.
NOM NOM NOM
This technology uses solar and hydro energy to power a conveyer belt that moves trash up into a dumpster. So far the TRASH WHEEL family has collected over 2,000 tonnes of trash, including over 800,000 plastic bags.
Mr. Trash Wheel
Gwynda the Good Trash Wheel of the West
Captain Trash Wheel
Professor Trash Wheel
Now I'm **REALLY** in Love!
Next we swim to Canada...
But my flippers are tired!
...where the Ocean Legacy Foundation assists communities in removing plastic pollution.
So far they have helped clean 671 kms of shoreline.
I always did like Canadians!
And then they use STEM practices to transform some of that waste into plastic pellets that can be turned into brand new products.
RECYCLED PLASTIC
I still need some sunglasses...


I'm glad that the humans are trying to clean up their own trash. But what are they doing to stop plastic from entering our oceans in the first place?
I'm glad you asked. C'mon!
Wait— where are we?!
We're in the Labs of GENECIS, a Canadian company that uses food waste to create BIODEGRADABLE plastic products! Like bags that can be composted instead of lasting 400 years, like oil-based plastic.
STEM
IN
OUT
Hey! Sea turtles don't really swim up sinks. This is a science magazine!
OOPS!
POP
But maybe the most important thing humans are doing to keep the oceans plastic-free is the simplest:
They're replacing plastics that are used just once with alternatives, like cloth shopping bags, glass water bottles, and reusable coffee cups. Plus they are avoiding plastic straws, cutlery, and food containers.
I CARE
TRASHY GRUB
And they're getting better at properly recycling whatever plastic they do use.
THOUGHTFUL HUMANS!
PLASTIC
You've finally convinced me, Baby Loggerhead. There is hope for the future of our ocean homes, after all.
In fact, the future is so bright I need to wear shades!
Now THAT looks good!



Students examining a model ocean to learn about currents in small systems

PHOTOS COURTESY OF PATRICK WELLS

A CONVERSATION ON CONSERVATION: PATRICK WELLS

BY CHELSEA KOWALSKI

Patrick Wells has spent the past 28 years teaching high school science, working with rural communities in Newfoundland, and fishing for cod on the weekends. As a strong proponent of student ownership and student engagement, he became a PhD candidate in Professional Learning at Memorial University to learn even more about student education practices. He spoke with *Root & STEM* about his perspective on how to implement ocean conservation in the classroom and why inclusivity is an inherent part of education.

• • •

How have you been able to bring ocean conservation lessons and practices into an educational environment? — It's been pretty easy here. We have quite an intimate relationship with the ocean in Newfoundland. Getting conversations started is one thing, but doing educational things is another. There are no fisheries that have never been overfished. We're not being sustainable with these populations. You can get into the reasons for that with the students by asking them questions. We have done things with a pond on school property that has sticklebacks and students can do a "mark and recapture" to keep track of the population. Local knowledge is also really important to bring in. For example, fishers know that if it's harder to catch fish, there are probably fewer of them. We've had major fish kills here on the island the past couple of years. When several million fish die, it's tantamount to an oil spill, because of all the oil in their bodies that gets released when they decompose. You can create a conversation around that: Why did it happen to many fish in one place? Excess oxygen consumption? Higher ocean temperatures because of the changing Gulf Stream and more warmth on the south coast?

Additionally, you can try to get students to bring their own stories forth by having things in your classroom that are from the ocean, like shells. The learning becomes more personal, because it connects with their experiences and their family's experiences. It's more complicated to make those personal connections with students. You can't do it by just standing in front of a class.

Would you say that there's something in general that educators could do to better support STEAM education in the classroom, particularly the arts? — It's a funny thing. I was not a fan of STEAM in the past. But I was involved with a project for which I created a painting of my dog—I'm really quite proud of it. I learned you can express data as art. There are activities I've done in the past, like having students go out to the pond and find items to put under the microscope so they can draw them and make a food web. We put up the students' art and they drew animals or insects on big sheets of paper and we decided where they were going to go in terms of the food chain and what they eat and all these great conversations were generated. So is there a place for art in STEM education? Absolutely. And it's about making that personal connection. Everybody loves to see their stuff up on the wall. They always take great pride in it. Especially for younger grades. It's really important to get them to make that cross into art because sometimes they will have trepidation about science. But if you can contribute with art, which everybody can participate in, then that is a good first step to becoming a part of the science that you're doing.

What would you say to educators who feel they could be doing more to meet the needs of their students but aren't quite sure where to start? — It's hard to start because you've got to commit to trying, and people are uncomfortable with making mistakes. You need to push beyond that boundary. The students won't get upset with you. It is invigorating for students to do something fresh. You really have to flip the whole discourse to have the students do the work. They're generating the knowledge, and you're there beside them asking formative questions. There are students who need you to take the time. That's one of the things I realized when I was doing my reflective writing. I was doing activities, but I wasn't reaching everybody.

One of the things I encourage people to do is ask students to make predictions, either publicly or privately. You can get them to write it down and ask why they made those predictions. You'll get a conversation. When somebody makes something personal, like a prediction or a drawing, those are the real moments. They create memories. And we're in the memory business.

How can educators better engage students who are struggling with STEAM subjects? — Engagement is really important. The more you know about somebody, the better you can talk to them. So, you've got to find out what's going on. And students are going to have bad days. But if you don't watch how they think, it's going to be very difficult for you to teach them. Students are the ultimate source of your knowledge as a teacher. You need to watch them and see how they respond. The look on their face, the tone of their voice, even if they're not making eye contact with you, can help you evaluate what's going on. Those types of things are really important in all classes, particularly in science, to find those people who are afraid of the subject. My prolific use of Play-Doh is the great equalizer because, at first, you'll see a whole bunch of snowmen and snails, and then you get down to what you really have to do.

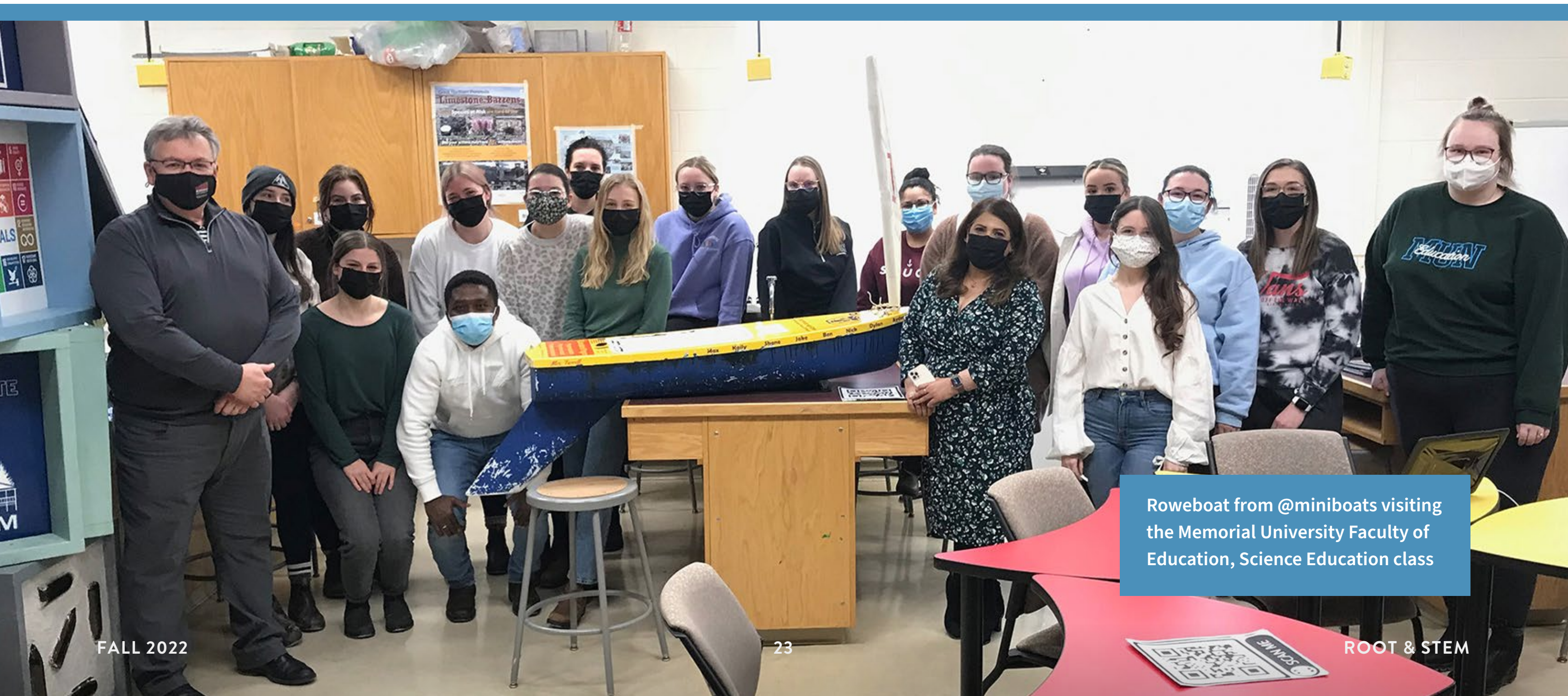
Do you have any advice for students who want to pursue a career in ocean conservation but don't have the confidence? — Confidence is a tough one. But if you love it, you gotta go for it, right? And don't be afraid. Try a science fair project. Visit places like research facilities or aquariums (like the Petty Harbour Mini Aquarium in St.John's) and meet with the people who work there. It's a great place to go learn stuff, but also just ask them personal questions. Talk to fishers. You hear a lot of very interesting things over the cutting table when you're coming in from fishing, and actually, sometimes really interesting research could be done. There are all kinds of monitoring stations all around the world where you can just go look at what research scientists are doing, like from Environment Canada and Oceans Network Canada. The Canadian Network for Ocean Education and the Canadian Ocean Literacy Coalition have all kinds of resources on their websites along with challenges that you can do.

How can educators create lesson plans and activities that are more inclusive and accessible? — Part of education is teaching students about people who have differences in mobility or senses. You need to put people in groups and mix them up so they can learn about other realities. And I tell them to focus on what they can do, not what they can't do. It's about getting out there and getting away from your lecture podium. Google Docs, for example, can be printed in braille. But that alone doesn't mean your course is inclusive. Class discussions and group notes won't be included in that and they are a big part of learning. You can't say "I'm a teacher now and I'm going to put it in park." If you do, you're in the wrong business.

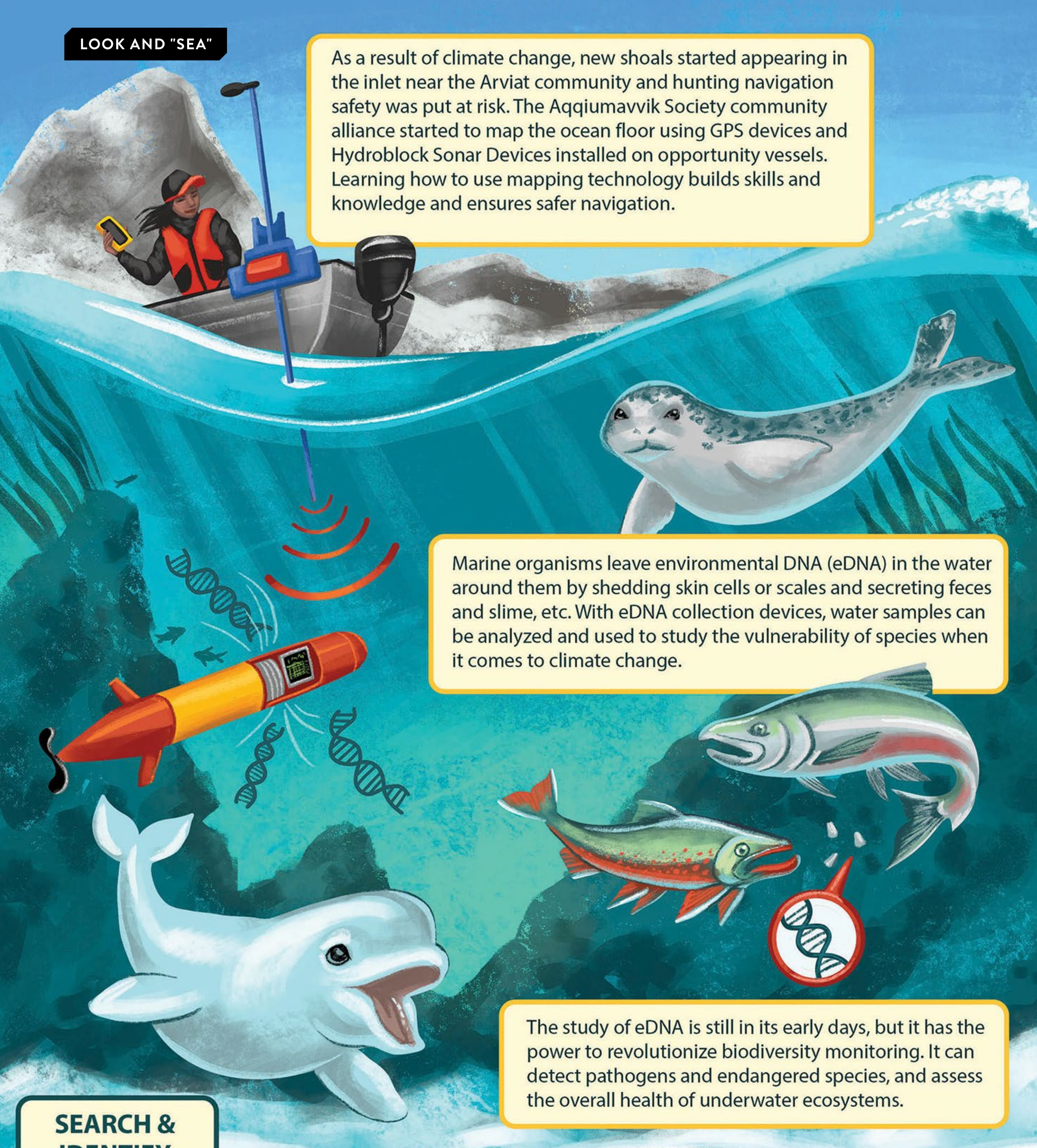
Touching, smelling, listening. Those are all important things. And learning has to be multi-sensory. Hearing the click of a beetle outside can be a lesson about scaring off predators and the students learn because they hear the click and they themselves get scared. But unless you're outside, you're not going to learn about what's around and how to protect what needs to be protected. &

The STEAM Makers section of *Root & STEM* showcases the different ways educators engage with students and promote STEAM concepts in and out of the classroom. If you know of an educator who goes the extra mile, tell us about them at **STEAM@pinnguaq.com**.

TECHNOLOGY AND SOCIETY



Roweboat from @miniboats visiting the Memorial University Faculty of Education, Science Education class



As a result of climate change, new shoals started appearing in the inlet near the Arviat community and hunting navigation safety was put at risk. The Aqqiumavvik Society community alliance started to map the ocean floor using GPS devices and Hydroblock Sonar Devices installed on opportunity vessels. Learning how to use mapping technology builds skills and knowledge and ensures safer navigation.

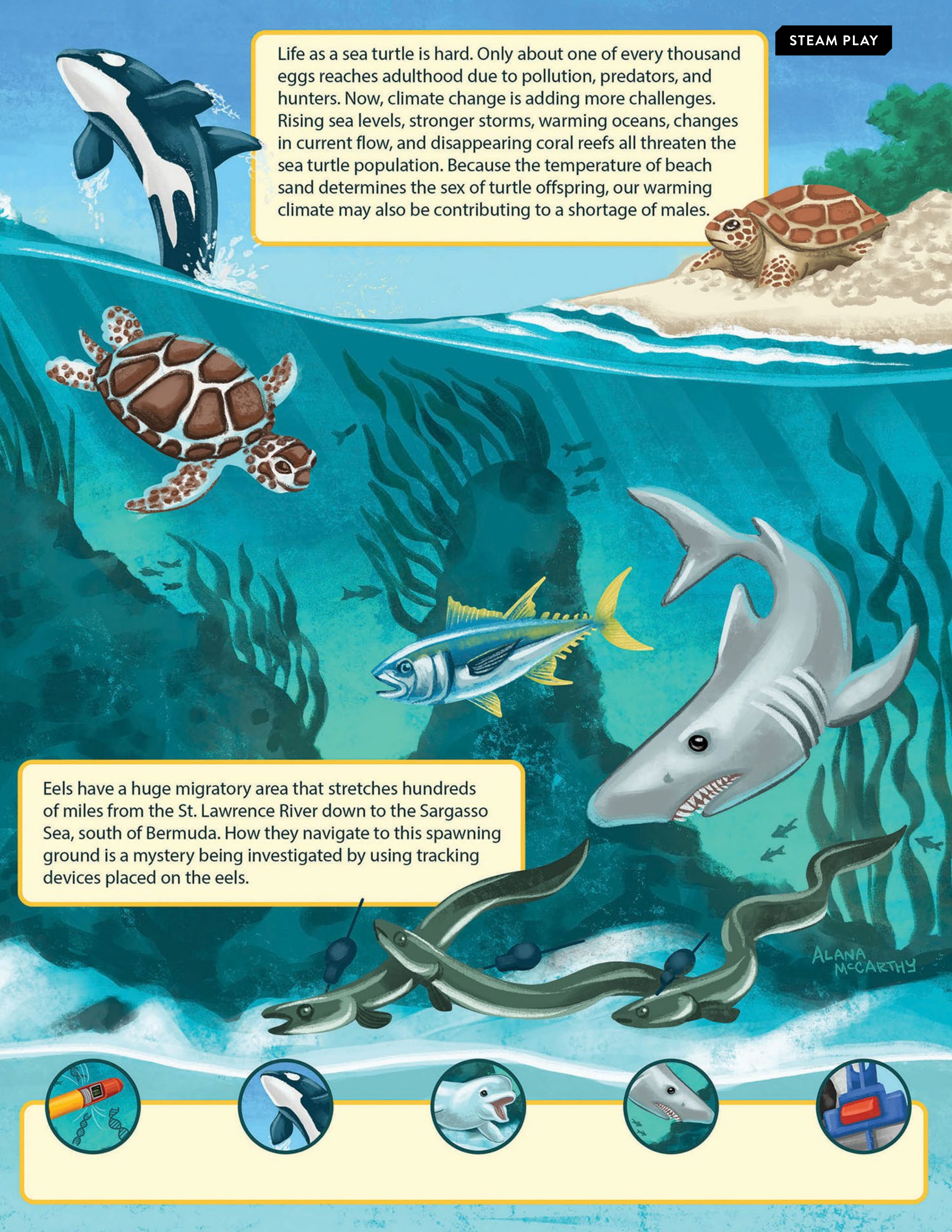
Marine organisms leave environmental DNA (eDNA) in the water around them by shedding skin cells or scales and secreting feces and slime, etc. With eDNA collection devices, water samples can be analyzed and used to study the vulnerability of species when it comes to climate change.

The study of eDNA is still in its early days, but it has the power to revolutionize biodiversity monitoring. It can detect pathogens and endangered species, and assess the overall health of underwater ecosystems.

SEARCH & IDENTIFY

Read the text above to identify the circled picture. Write your answer below each picture.

Life as a sea turtle is hard. Only about one of every thousand eggs reaches adulthood due to pollution, predators, and hunters. Now, climate change is adding more challenges. Rising sea levels, stronger storms, warming oceans, changes in current flow, and disappearing coral reefs all threaten the sea turtle population. Because the temperature of beach sand determines the sex of turtle offspring, our warming climate may also be contributing to a shortage of males.



Eels have a huge migratory area that stretches hundreds of miles from the St. Lawrence River down to the Sargasso Sea, south of Bermuda. How they navigate to this spawning ground is a mystery being investigated by using tracking devices placed on the eels.

BY JESSICA LEEDER

Unearthing What Swims —or Slithers— Beneath

How DNA technology is helping ocean scientists reach new depths

PHOTOS COURTESY OF EDNATEC

Left: eDNA water samples are collected at a marine site by eDNAtec's field staff outside of St. John's harbour. Top: eDNAtec scientists have eDNA expertise from samples to sequences to data interpretation

Many of us know what it feels like to peer into a body of water—a mud-bottom pond, one of the Great Lakes, the frothing ocean—and wonder what lurks way down beneath. What mysterious habitats exist in those murky places? The complete answer to this question still puzzles scientists all over the world. For years, the creatures that swim, slither, and skitter their way through the deepest waters on Earth have evaded even the most determined research scientists. That's because studying the depths of the ocean is nearly impossible. The traditional technology we use to explore the ocean—boats, trawl nets, underwater cameras, submersible robots—cannot typically extend to the deepest parts of the sea floor.

Lately though, scientists at a new, landlocked laboratory in St. John's have been working on a new way of finding out what lives in the deep sea, one that requires researchers to look closely at the water (albeit through some very fancy microscopes). Through those high-tech lenses, they aren't looking for fish scales or bits of lobster shell. They're hunting for microscopic traces of cellular material known as environmental DNA (eDNA). Just as we humans leave fingerprints on surfaces we touch, or some of our skin cells rub off on straws we drink from, waterborne life forms, from tiny plankton to giant whales, leave traces of DNA in the water. Those breadcrumb-like trails are now being quietly uncovered in St. John's. At eDNAtec, lab researchers can speedily detect the DNA of hundreds, and even thousands, of organisms in a single cup of water. The relatively new technology they use to do it is called metabarcoding. Already, it has led to discoveries of many living things that humans have never seen before, including organisms from some of the deepest and most hard-to-reach parts of the sea, located in the North Atlantic Ocean.

"The ocean is full of things that we haven't even been able to describe yet," says Nicole Fahner, Associate Director at eDNAtec. "There's just more diversity of things than there are taxonomists with time to go and do the work to name them as species."

Fahner and her team at eDNAtec have spent the last few years analyzing water samples as part of the Ocean DNA System Project. It brings together scientists from

eDNAtec's field team collect samples in a tropical forest for an environmental baseline survey in collaboration with local stakeholders

Fisheries and Oceans Canada (DFO), the Nunavut Fisheries Association (NFA), and Energy Research and Innovation Newfoundland and Labrador. The goal of this collaboration is to figure out how eDNA can be used to help monitor the ocean with more precision and less invasiveness. While each partner is interested in protecting the ocean environment, they also want to grow the ocean-related economy safely, adding jobs to industries, such as oil drilling, fishing, and more. Before they can do that though, they need to understand more about exactly what is living beneath the surface.

"You can't protect and sustain something you can't measure," says Fahner.

• • •

The fact that DNA can be used at all to help monitor ocean life is thanks to work started by another Canadian scientist, Paul Hebert. A renowned biologist at the University of Guelph, Hebert gets credit for coming up with the concept of assigning barcodes, similar to the codes scanned on food packages at the grocery store, to every identifiable species in the world. The idea was to develop one massive catalogue of barcodes accessible to everyone in the world. That catalogue is known now as the International Barcode of Life (available at ibol.org); it is essentially a global reference library of millions of DNA sequences accessible online. Currently, there are more than 700,000 species catalogued; the goal is to increase that number to 2.6 million by 2026.

Ocean scientists use the Barcode of Life to help identify sequences of DNA they discover in various environmental samples, including sand, soil, and water. While the barcode's existence has dramatically sped up biodiversity research related to the ocean, scientists are still "not even close" to documenting all underwater life forms, says Dirke Steinke, Associate Director for the Centre for Biodiversity Genomics at the University of Guelph.

"We understand some other planets better than our ocean floor," he laments. "It's staggering." And Steinke would know. He was part of a global team of 2,700 scientists that undertook the Census of Marine Life, a massive, 10-year effort in which scientists all over the world set out to assess and categorize a huge spectrum of life in the ocean, from microbes to whales. Their work resulted in the creation of the first-ever inventory of marine life, which was made public in 2010. At that time, the inventory included more than 30 million records. Despite that mammoth number, Steinke says there is much left to discover. One example on the scientific bucket list is the depths of the Labrador Sea, a deep and frigid arm of the North Atlantic Ocean between Canada and Greenland that is clogged with ice for much of the year. Scientists have dubbed the hard-to-reach spot one of the "lungs of the sea" because it is one of few places where oxygen is pulled out of the atmosphere and down into the deepest part of the ocean. Through a process called deep water convection, the oxygen is redistributed below the surface throughout the Atlantic, Pacific, and Indian Oceans. That oxygen is essential to life forms at great depths. Evaluating the health of this vital area is a very difficult task; DNA testing of water samples could make it much easier than trying to use drag nets to catch specimens for sampling as explained by David Cote, a research scientist with Fisheries and Oceans Canada (DFO).

"You don't necessarily need a big fishing boat or a trawler to go and collect a water sample," says Cote. "All you need are some rubber gloves and to be able to scoop up some water and send it to the lab."

If what Cote says is true, it means DNA sampling opens the door to just about anyone interested in helping collect water samples—students, say, or anyone living or working in a remote destination with access to water. In fact, one of the main goals of the Ocean DNA System project is to ensure that protocols for taking water samples do not require high-tech science training or cumbersome equipment. Ideally, samples can be easily taken and sent to the lab by just about anyone, anywhere. Achieving that goal could both reduce the costs of expensive scientific treks and widen the lab's access to ocean water samples—which would also mean communities who send in samples will have a clearer picture of what lives in their waters.

"The goal is to develop a protocol that could be deployed on a commercial fishing

"The knowledge gaps [on inshore fish populations] are huge and we're looking at how we can fill them. You start with traditional knowledge and build that up, working with communities. Environmental DNA is one of the tools we can use."

—Brian Burke,
Executive Director of the NFA

vessel without a scientist present," Fahner says. "We wanted to make something really straightforward and easy to follow, something that doesn't require a very elaborate piece of equipment. Fishing vessels are already going out where the fish are, so it just makes sense," she says, adding: "With oceans, a lot of the challenges are just getting to the spot you want to monitor. Why not use boats that are already going out to help answer the questions?"

In northern and remote locations, where using boats isn't always an option, the collection protocol opens up the possibility of engaging community members to participate in gathering samples, including Indigenous groups who know their land—and water—better than any outsiders. DNA analysis, Cote adds, might even enhance local knowledge. "Labs can send you back a record of all the different animals that are living on your doorstep," he says, adding: "There may be important habitats for that particular community."

In Nunavut, there are high hopes that eDNA will shed light on sensitive species that could benefit from more precise monitoring, as well as some new possibilities for commercial fisheries. In May, the Nunavut Fisheries Association and eDNAtec signed an agreement to continue working together beyond the Ocean DNA System project, which will soon wind down. Brian Burke, executive director of the NFA, says there is a lot of room for the development of the inshore fishery in many communities in Nunavut. While communities would benefit greatly from growing their ocean-related economies, scientific information on local fish populations has been limited.

"The knowledge gaps [on inshore fish populations] are huge and we're looking at how we can fill them," Burke says. "You start with traditional knowledge and build that up, working with communities. Environmental DNA is one of the tools we can use."

In the longer term, Burke's hope is that several communities will develop their fisheries into viable economies. "There's big socio-economic potential for those communities," he says, adding that even if commercial fisheries aren't established, identifying resources for community food security is just as important. Burke says the NFA is also working to get fisheries and marine careers—and the potential those careers hold for young students—into Nunavut's school curriculum. "There's very little information now on the potential for careers in the fishery or marine sectors," he says. "We know there's a large number of young Inuit who will come of working age over the next few years and we'd like them to know opportunities exist in the industry. It's a real option for them." Burke's worry is that fisheries and marine careers risk being seen as a last resort pathway for kids.

"That's changed," he says. "We're adopting technology now. We need people on our vessels with digital skills. It's not the old fishery of the past."

"What eDNA can do, its advocates argue, is help Canada refine its approach to protecting the oceans it borders during a time of significant environmental pressure."

While no one is advocating that traditional technology be cast off, ocean scientists increasingly see a future that includes DNA analysis as part of their research kit.

"We are getting a whole bunch of information on understudied species that probably have a big impact on the overall ocean's ecology ... that, in turn, might help us understand how they're affecting or impacting the abundance of the species that are really important to industry," says Cote. Other species, such as corals or sponges that create important habitats but are typically not sampled by trawl surveys because of their sensitivity, can also be detected by DNA. The same is true of what Cote calls "important nursery zones" for commercial fisheries, which are zones too shallow or sheltered for trawling. Conducting water sampling in those areas could broaden researchers' understanding of the habitat support required by a particular fishery without jeopardizing its health.

Despite the benefits of eDNA, there are answers it is unable to give—for now. At the top of that list is what ocean scientists refer to as "abundance," which is a measurement of how many of a certain fish are actually in the water. In cases of commercially important species—cod, for example—regular science assessments are conducted to monitor the impact of fishing, predators, and other environmental and climate conditions on fish populations. Those assessments tend to require the use of large research vessels, trawlers, robotic submersibles. and other expensive technologies. They are also fairly invasive, in that they involve hauling fish and bycatch out of the water. But there is no way around them, says Cote, because environmental DNA can only tell us whether a fish is present (or was present recently enough to have left behind genetic material). It offers no hints as to the size of a fish population.

"It's not a perfect technology alone, nor is any other conventional technique," Cote says.

Although surveys that involve removing fish from the water are more destructive, they do allow scientists to test specimens for containment loads and to assess the age and size of the animal. "Those kinds of things are really important when we're trying to understand the health of a population and you can't get that right now from eDNA."

What eDNA can do, its advocates argue, is help Canada refine its approach to protecting the oceans it borders during a time of significant environmental pressure. The easy-to-get nature of water samples makes it easy to use them to establish benchmarks against which ocean sustainability can be measured over time. This argument is put forward by Mehrdad Hajibabaei, the founder of eDNAtec. Hajibabaei is concerned that Canada's current approach to protecting sensitive environmental areas in Canada is insufficient and inconsistent. This is in spite of the fact that Canada is working to preserve 30 per cent of its coastal territories as Marine Protected Areas (meaning they are legally set aside for conservation from the seafloor to the surface) by 2030.

"What will we do to measure and confirm that we really are protecting these areas?" Hajibabaei wrote recently. "The current data collection tools that we have are fantastic but simply not enough," he wrote. "eDNA can be added to the toolbox to … precisely measure the biological layers of any ecosystem."

Imperfect as it may be, one thing is clear: eDNA has given us a window into many forms of ocean life that, until recently, we had no means of viewing. Now that we can see into deeper depths, we can step up efforts to protect and sustain our oceans. &

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eDNAtec's genomics team uses state-of-the-art sequencing platforms, including the Illumina NovaSeq 6000, to provide deep insight into biodiversity within every sample

GLOSSARY TERMS

Environmental DNA—Often shortened to eDNA, this is DNA collected from samples in the environment, including water, soil, or air, instead of from a living organism. Like humans, organisms shed DNA in their feces, hair, skin, etc. Collecting and analyzing eDNA allows scientists to monitor endangered or hard-to-find species without collecting a living organism, which can cause undue stress and even death.

Metabarcoding—The process of identifying unique DNA sequences from many different organisms at the same time, within the same sample, and connecting them to a barcode. This process allows ocean researchers to detect hundreds and even thousands of life forms in the same cup of water.

Barcode of Life—A publicly accessible reference catalogue that aims to contain genetic sequences from all species of life. Scientists use the Barcode when they are analysing environmental DNA to confirm the identities of known and unknown organisms.

DNA Sequence—The order of nucleotides (also called bases) in the long molecule that contains an individual's genetic code.

FEATURE

UNLOCKING TUNA

BY KAREN PINCHIN

Two hours after untying from downtown Halifax's dark harbour, the Pelagic Predator—a white, 15-metre fishing vessel captained by 38-year-old Camille Jacquard—rumbled atop a patch of Atlantic Ocean called the Darby Bank. On this bright fall day in 2020, the rising sun sparkled on a horizon of steel-blue waves. Steering the newly built vessel with easy confidence, Jacquard wore his usual necklace: a gold charm of a leaping tuna.

To fill his commercial quota for Atlantic bluefin tuna, Pelagic Predator captain Camille Jacquard uses an electrified harpoon to kill each fish, a technique that can fetch higher prices on the Japanese market.

With three children to support and bills to pay, Jacquard fishes for a living year-round, including for lobster and swordfish; sales of bluefin tuna to well-heeled buyers in Japan comprise only a small slice of what he earns every year. His prowess in finding and catching the huge, deep-diving fish has won him trophies and accolades, but he also loves taking part in the data-gathering that is helping scientists understand and protect Atlantic bluefin populations.

Over the past three decades, ambitious tagging and tracking collaborations between commercial fishermen and research scientists across Canada have transformed the reach and scope of ocean conservation. The work is a delicate dance of trust and money, pride and accountability. And it's why, instead of catching and killing the first giant tuna they landed that day, Jacquard and his crew instead planned to tag it and set it free.

For generations, Jacquard's Acadian ancestors watched some of the biggest fish in the world school off Nova Scotia's jagged coast. Back then, the biggest bluefin in Canadian waters grew to more than two metres long and weighed in at more than 350 kilograms, the weight at which they were dubbed "granders" instead of simply "giants." In 1979, an angler named Ken Fraser landed a 675-kilo bluefin near Auld's Cove, Nova Scotia. It was the biggest Atlantic bluefin ever recorded, and likely the last of its size. Throughout the 1970s and 1980s, demand for bluefin flesh for the Japanese sushi market hollowed out the species, earning fishermen and distributors millions of dollars. The boom also sparked a population crisis that led to serious concern in the 1990s and 2000s that bluefin could go extinct within a generation. In 1993, international tuna scientists warned that Atlantic bluefin populations off the United States and Canada had plummeted 90 per cent from 1975 levels.

Part of the challenge with gathering data on bluefin populations, says Acadia University bluefin expert Mike Stokesbury, is that the powerful, warm-blooded fish ranges so widely that it has been hard to gather data on where it travels, spawns, and feeds. Without sufficient data, fisheries managers and governments have long struggled to calculate appropriate limits to how many bluefin, and at what sizes and in which seasons, can be sustainably pulled from the ocean. Which is why, he says, tagging collaborations with fishermen like Jacquard have proved vital.

"In 1995, no one would ever have thought you could catch a fish off Cape Breton and then you could catch a fish off Ireland and they might be from the same stock," says Stokesbury, who helped co-found the Halifax-based group Ocean Tracking Network (**oceantrackingnetwork.org**). That group compiles and stores much of the world's fish tracking data for hundreds of species and has deployed more than 2,000 tracking receivers across five oceans alongside seven continents.

Fish tagging is a simple process of marking a fish and then waiting for it to be caught again, a technique first formally practised in the mid-1800s by wealthy Scottish landlords curious about the provenance of salmon in their rivers. In the mid-1950s, a wartime naval architect-turned-biologist named Frank Mather III pioneered the first research project to track Atlantic bluefin. While troubleshooting his equipment alongside fishermen who fished for a living, Mather invented the first plastic dart strong and sturdy enough to lodge firmly in the body of a fast-swimming tuna.

More recently, advances in tagging technology include acoustic tags that ping off underwater receivers and can last for up to seven years, pop-off satellite tags that gather data and then eject toward the ocean's surface to dump data toward satellites, and tiny tracking chips as small and thin as fingernails powered by tiny batteries initially developed for cell phones. These devices have revolutionized our understanding of a wide range of species, from the Sargasso Sea-spawning American eel to the highly migratory bluefin.

In the mid-2010s, back when Stokesbury first started tagging tuna alongside renowned researcher Barbara Block and her Tag A Giant (**tagagiant.org**) program out of Cape Breton's Port Hood,

"Over the past three decades, ambitious tagging and tracking collaborations between commercial fishermen and research scientists across Canada have transformed the reach and scope of ocean conservation. The work is a delicate dance of trust and money, pride and accountability. And it's why, instead of catching and killing the first giant tuna they landed that day, Jacquard and his crew instead planned to tag it and set it free."

An Atlantic bluefin is dragged alongside the Pelagic Predator before being tagged

many fishermen deeply distrusted their group and their methods. “A rumour when I first started was that we were putting tags on them so they would swim to the States and show the US fishermen where the fish were,” he says.

It took weeks, sometimes years, for them to convince the members of the Port Hood community that their main objective was simply to understand more about tuna and its life cycle, not to interfere with livelihoods. “The valuable part of bluefin tagging, in my mind, is just to tease out the mixing rates and stock structure so that we’re able to properly quantify what fish are being taken out,” says Stokesbury.

In 2002, Camille’s father, Eric Jacquard, the then-president of the Southwest Nova Tuna Association, met an ambitious Massachusetts-based bluefin researcher named Molly Lutcavage. The pair hit it off and started working together to tag tuna every fall with the scientist’s Gloucester-based Large Pelagics Research Program (**tunalab.org**) team. Even when Lutcavage wasn’t on board, Eric and Camille often inserted old-fashioned streamer tags (sometimes also called spaghetti tags) into fish that were caught but weren’t the right size or quality. More data, they figured, was better than no data.

Back on that fall 2020 day, as they headed to the Darby Bank—where they knew the bluefin would pursue huge herring schools—Jacquard’s crew rigged up ropes to the Predator’s white, hinged, tuna-fighting chair. Camille only had three commercial tags left that season, so he was feeling the pressure to select the highest-quality round, fat fish to land and sell that day.

Within minutes of dropping the first baited lines into the water, one of the boat’s long rods sprang with a violent hit. The reel’s drag screamed as a bluefin pulled coloured line off its huge spindle. Eventually the fish slowed, and the angler-in-training slowly started to retake lost ground. “Every inch counts,” said Eric, nodding his head. Watching the inexperienced angler lurch and puff, he quickly intervened. There’s a trick to the fighting chair, he advised: pull backwards, then tip its hinge quickly forward while reeling spurts of line back onto the reel.

For nearly an hour, the fish remained invisible, running deep in the ocean, gradually conceding line until it breached the surface with a violent, silvery flick of its tail. In the meantime, the boat’s radar filled with more tuna. We were in the thick of them. From one brief glimpse, Eric estimated the fish on the boat’s line likely weighed 270 kilograms. As the angler drew the fish closer and it thrashed its enormous tail, Jacquard’s first mate, Matthew Corporon, extended a metal gaff and line running out from the side of the boat. They wanted to hook into its mouth and hold it still.

“We aim for 100 per cent survival on tagging,” Camille said, as Corporon jabbed a long stick—preloaded with an identifying

Fishers Eric Jacquard and Matthew Corporon tend to lines, nestled in holes drilled into a picnic table, aboard the Pelagic Predator

Left: Camille and Eric Jacquard tagging a bluefin tuna off Port Hood, Nova Scotia—the fish is on deck to get measured, tagged, and then returned to the water. Right: Charter clients get a taste of bluefin tuna sashimi as Eric Jacquard slices up a cut from the head as a mid-day snack

"Fishers regard having more collective knowledge as a blessing, not a curse, as scientists—and bluefin as a species—increasingly benefit from fishers' hard-won generational knowledge and expertise."

tag attached to a plastic anchor—into the tuna's back. The plastic piece lodged firmly, near its dorsal fin, as the proud angler and his buddies snapped photos over the side of the boat, straining to get both man and giant creature in the frame.

For hours, the group caught, tagged, and set tuna free, until Jacquard decided it was time to harvest the final three fish to fill his commercial quota. For that, he used an electrified harpoon to shock and kill bluefin drawn by chumming, the dropping of dead fish parts, off the side of the Predator's hull. The technique, his Japanese buyers had once informed him, means higher-quality flesh and a better price on the docks.

"The community of fishers who catch big fish is a vibrant one," Fisheries and Oceans Canada (DFO) biologist Dheeraj Busawon says, although, like Stokesbury, he also encountered an initial reluctance by commercial fishers to participate in DFO's sampling programs. They started with two participants in 2010; they're now up to 15 fishers in a good year. "The whole goal is to better manage the resource, [and] the better your data inputs, the better your models," he says. Instead of being afraid of the data, he has increasingly noticed that fishers, like the Jacquards, regard having more collective knowledge as a blessing, not a curse, as scientists like himself and Stokesbury—and bluefin as a species—increasingly benefit from fishers' hard-won generational knowledge and expertise.

Halfway through Jacquard's last bluefin-fishing day in 2020, they picked up additional herring bait from a boat floating nearby. They released the bait together and a rush of bluefin followed eagerly, some jumping clear out of the water in magnificent arcs before landing with huge splashes. "Does this fish look endangered to you?" Eric Jacquard shouted at me, flashing a huge, confident smile. At that moment, all I could do was smile back, and hope that one day, the data might prove him right. &

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- Lesson plans
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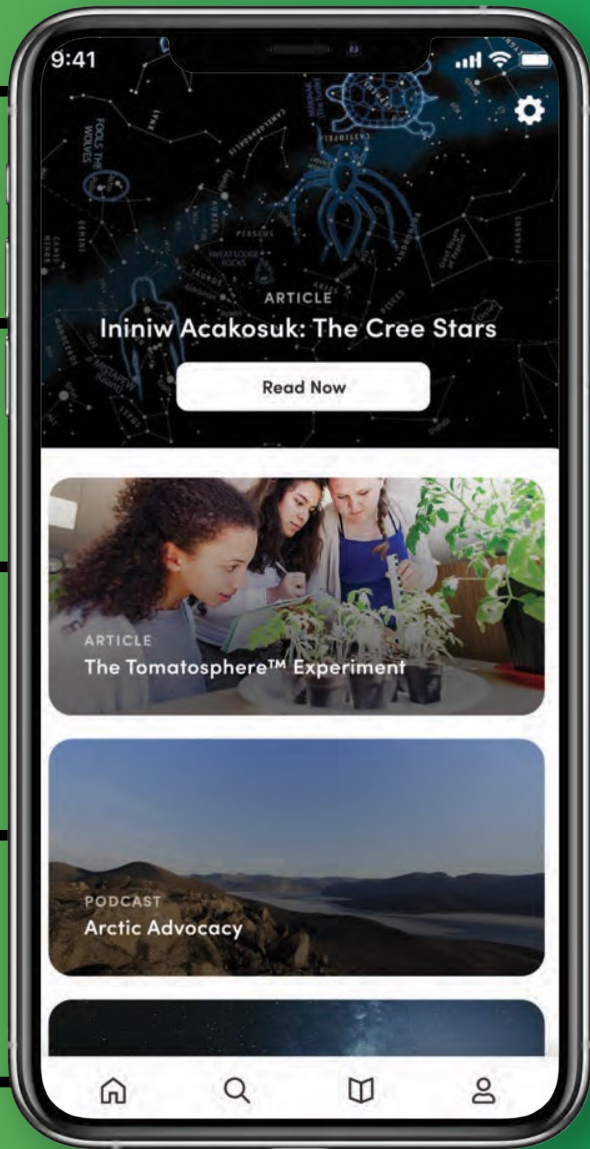

We're excited to launch the Root & Stem app for iOS and Android, designed to put innovative STEAM education tools and information in the palm of your hand!

Be the first to know (and download) - simply scan this QR code to receive the launch announcement:

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PHOTOS COURTESY OF BRANDON BUNNIE

Digital Kit

Screenshots from Sea Tangle, an interactive game where users can dive, swim, explore a kelp forest, and learn about the sea creatures within it

PAST ISSUES

If you missed the past issues of *Root & STEM*, you can find them online at
pinnguaq.com/root-stem

RESOURCES

We have developed additional digital resources for educators to use in their classrooms that connect to the theme of Ocean Conservation—including lesson plans, video tutorials, and handouts. They can all be accessed online via the links that follow.

Root & STEM Podcast

The podcast expands on our publication, *Root & STEM*, and invites subject experts from the issue to share knowledge. The episodes are approximately 15 minutes long and are available on the Pinnguaq website, and through popular podcast platforms, such as Apple and Spotify.
pinnguaq.com/learn/the-root-stem-podcast

Introduction to GPS and GPS Devices

The Introduction to GPS and GPS Devices video is an engaging resource for learning about the Global Positioning System (GPS) and how GPS devices can be used to improve our everyday lives. This video explores the history and origins of the GPS, how GPS devices work, and what this incredible technology means for scientists and citizens all over the world.
Introduction to GPS Devices: **youtu.be/Nlpnl6VFKcc**
pinnguaq.com/learn/courses/introduction-to-gps-devices

Mission Ocean: Ocean Conservation YouTube Series

This series explores topics affecting oceans and marine life, like plastic pollution, overfishing, and environmental DNA research. It encourages everyone to think about the impact of our actions on our waterways and how to make environmentally friendly choices to do our part for ocean conservation. Each video promotes an understanding of some of the critical threats to our oceans and how modern-day methods and technologies are helping save our oceans and protect our planet's future.
pinnguaq.com/learn/ocean-conservation-series

Sea Tangle

Sea Tangle is an interactive game that allows users to explore a kelp forest off the coast of British Columbia. Players learn why the kelp forest and its inhabitants are important to one another. This experience includes knowledge from a member of the Haíłzaqv Nation, who took the time to share their knowledge and experience in Ocean Conservation. This journey can be taken as a solo player or with a group. Once the learning adventure is complete, the host of the game can then choose to play a game of hide-and-seek, with the hiders turning into the creatures they just learned about. Good luck hunting in Sea Tangle!
pinnguaq.com/learn/sea-tangle

Message to Educators

The lessons in this issue are located at the intersection of Inuit and Western knowledge and perspectives. Etuaptmumk is the Mi'kmaq word for Two-Eyed Seeing: An Indigenous epistemology that teaches us to incorporate both Indigenous knowledge and Western knowledge in our learning practice. This approach is exemplified by the work of Enooyaq Sudlovenick, an Inuk researcher and the subject of the podcast accompanying the first lesson.

This lesson series was also inspired by the life and work of Danielle Moore, who devoted herself to ocean conservation and equitable access to STEAM education for all. We are grateful to uphold her legacy by engaging learners from coast to coast to coast in the good work of becoming stewards and protectors of the waterways that are the source of all life on this marvelous blue dot.

We hope that the learning journey you will take with your students shows you that there is magic to be found where the water meets the wires.

— **UJARAK APPADOO AND TESS SUTHERLAND**
Curriculum Lead and Digital Skills Educator

Lesson 1

Grade Level: 3–6

Introduction to Nattiit (Ringed Seals)

Overview

In this lesson, students learn about nattiit (ringed seals) from both a biological and an Inuit perspective. Students gain a holistic understanding of how these marine mammals interact with their Arctic environment and how they are a part of regular life in the North. Accompanying this lesson is a podcast with Inuk researcher Enooyaq Sudlovenick, in which she discusses her interest in nattiit and how to incorporate both Inuit Qaujimajatuqangit Principles (Inuit guiding principles) and Western knowledge. The lesson concludes with a brief introduction of the micro:bit and MakeCode environment to prepare learners for the activities that follow.

Learning Objectives

- Learn about nattiit and how they are part of Inuit life
- Learn about the basic habitat of nattiit
- **Avatittinnik Kamatsiarniq:** Respect and care for the land, animals, and the environment

Inuit Qaujimajatuqangit Principles

Note: *Sometimes known as IQ principles, or Inuit guiding principles. It should be noted that the spelling of Inuit terms often differs, according to dialectal differences. The concepts remain shared despite spelling differences (Tagalik, Shirley. **pinnguaq.com/learn/inuit-principles-of-conservation-serving-others**).*

Qanuqtuurunnarniq (Being resourceful to solve problems): When hunting nattiit, Inuit hunters use a naluaqtuut (a sharp hunting tool) to get close to an individual nattiq (ringed seal). They place a feather over the nattiq's breathing holes in the ice to see when they are about to surface.

Avatimik Kamtsiarniq (Promoting environmental stewardship): Inuit use all the parts of nattiit. Clothing is made out of the sealskin so nothing is wasted.

Pijitsirniq (Serving): A hunter who catches a nattiq always shares it with other people. By catching the nattiq, hunters are serving their community by providing food.

Tunnganarniq (Being welcoming, open, and inclusive): If a hunter catches a nattiq on the ice, the hunter welcomes the other hunters in the area to have tea and fresh nattiq liver.

Pilimmaksarniq/Ikajuqtigiinniq (Working together for a common cause): The important skills needed for harvesting and preparing the nattiq are taught to the younger generation through observation and practice.

Vocabulary

- **nattiq** – ringed seal
- **nattiit** – ringed seals
- **Inuit nunangat** – land where Inuit live
- **nanuq** – polar bear
- **nanuit** – polar bears
- **tiriganiaq** – Arctic fox
- **tiriganiat** – Arctic foxes
- **naujaq** – seagull
- **naujait** – seagulls
- **siggu** – snout
- **umiit** – whiskers
- **iggiaq** – esophagus
- **kanivautik** – diaphragm
- **kukik** – claws
- **puvait** – lungs
- **tinguk** – liver
- **aqiaruq** – stomach
- **sungaq** – gallbladder
- **inaluat** – intestines
- **niaquq** – head
- **qisik** – skin/fur
- **uummatik** – heart
- **taliruq** – fore flipper
- **saaminiit** – front ribs
- **uqsuq** – fat
- **itiq** – anus
- **saqpik** – back flippers
- **naluaqtuut** – a sharp hunting tool made from a white material with a wooden frame and a handle

Materials

- Podcast with Enooyaq Sudlovenick sharing her perspectives on incorporating both Inuit and Western knowledge into her work. The *Root & STEM* podcast can be found where you listen to your podcasts, as well as on the Pinnguaq website (**pinnguaq.com/learn/the-root-stem-podcast/arctic-advocacy**)
- Nattiq poster and worksheet (download at **pinnguaq.com/learn/introduction-to-nattiit#materials**)
- Memory Game about the nattiq (available at **pinnguaq.com/learn/introduction-to-nattiit**)

Storytime

Before starting the lesson, read the students a story about nattiit. Any one of these suggested stories is appropriate to the lesson.

- *All About Seals* (**inhabiteducationbooks.com/products/all-about-seals**) by Ibi Kaslik
- *Aglu Hunting* (**inhabitmedia.com/2014/01/01/aglu-hunting**) by William Flaherty and Malcolm Kempt
- *Palluq and Inuluk Go Hunting with Their Ataata* (**inhabiteducationbooks.com/products/palluq-and-inuluk-go-hunting-with-their-ataata**) by Jeela Palluq-Cloutier, illustrated by Michelle Simpson

Introduction and Know-Want-Learn Exercise

Nattiit are marine mammals that are integral to Inuit all across Inuit Nunanganit. In this lesson, we look at what nattiit are, their habitats, why they are hunted by Inuit, and how Inuit consume and use them.

To start the lesson off, ask the students to create a Know-Want-Learn (KWL) chart.

- **K** – What I **know**
- **W** – What I **want** to know
- **L** – What I **learned**

Before the lesson starts, students write or draw what they already know about nattiit and what they want to know about them (leave the "L" section until the end of the lesson). Once they have written that down, ask a few students to share their charts with the whole class.

Listening Activity

Enooyaq Sudlovenick is a PhD student whose research focuses on marine mammals and Inuit Qaujimajatuqangit. Listen to this podcast to learn about her research with the nattiq and how she considers both Western knowledge and Inuit Qaujimajatuqangit in her approach to research.

Discussion Questions

1. What are some of the ways the nattiq is important to Inuit?
2. How did Inuit Qaujimajatuqangit change the approach to research with regards to the nattiq project?
3. What are some of the changes we see in the ocean when temperatures increase?
4. What were some of the observations Enooyaq found in the tissue samples of the nattiq?
5. How might IQ principles change approaches to conservation?

What are Nattiit?

Depending on what students indicated they already know about nattiit, either review the following information or provide a more detailed lesson.

Nattiit are animals that live in the ocean and rely heavily on sea ice. They are mammals that live in the Arctic and can be found as far south as northern Japan. The length of a nattiq is 1.5 metres and they weigh between 50 and 75 kilograms. Their main diet is fish and invertebrates. Nattiit are grey with black spots with white around the spots, which are surrounded by light grey rings. They can live for up to 30 years. The population of nattiit varies but there are approximately 2,000,000! Nattiit breed annually from April to May. Known predators of nattiit are nanuit (polar bears), tiriganiat (Arctic foxes), and Inuit.

Where Nattiit Live

We are looking at nattiit that live specifically in the areas where Inuit live and consume nattiit, but nattiit are located all across the Arctic.

Nattiit live in Arctic waters and are commonly found on ice floes. Floes and pack ice are used for resting, pupping, and moulting. Nattiit do not like to come ashore but prefer to inhabit areas near the breathing holes they create in the ice or ice cracks so they can escape predators easily. Arctic sea ice is integral to their survival.

How Inuit Use Nattiit/ Innovations

Inuit use all of the nattiq. Nattiit are a major element of Inuit diet and clothing. To get a better understanding of how nattiit are used, we will look at how Inuit hunt, consume, and use them.

Students learn the different parts of the nattiq, which parts are eaten, how each part of the fur is used, and for which garments. Show the students the nattiq poster and discuss the body parts of the nattiq. Ask students which parts of the nattiq they have eaten.

- **Innovation:** Sealskin is adapted to the Arctic environment. The fur is waterproof and very warm. Inuit have observed this and use the fur to make warm, waterproof clothing, such as kamiik (boots), parkas, amautiit (a baby carrier), and pualuk (mittens). Inuit have also used uqsuq (nattiq fat) to fuel the qulliq (the light source and cook top inside an igloo).
- **Food**: Nattitt are rich in nutrients. Nattiit contain vitamin A, which helps humans see in the dark and provides protection against infection; vitamin D, which builds strong bones; omega-3 fatty acids, which are important for brain development and help the heart and blood vessels work properly; zinc, which helps in fighting infections and healing wounds; iron, which is essential for blood; and selenium, an antioxidant that prevents cells from being damaged.
- **Crafts**: Using sealskin scraps has taken new forms of crafting, from creating jewelry, like earrings and necklaces, to making small pouches and bags, all of which contributes to the Inuit economy.

Completion of "L" Portion of KWL Chart

- **Task 1** – Students complete the "L" part of their KWL by adding a few points about what they learned in this lesson
- **Task 2** – Using the nattiq worksheet, have students label the parts of the nattiq

Nattiq Anatomy Tech Activity

After learning about the parts of the nattiq, divide the class into small groups or pairs. Assign each group one part of the nattiq and challenge them to display its name in Inuktitut on their micro:bit.

The full tech activity can be found on the Pinnguaq website (**pinnguaq.com/learn/introduction-to-nattiit**).

Conclusion

Digital Memory Game Activity

Visit the Pinnguaq website to play the ocean conservation memory game! Here students will learn all about nattiit and why ocean conservation is important.

Resources

- Facts about Seals (**worldwildlife.org/species/seals**)
- Researcher Enooyaq Sudlovenick (**macleans.ca/society/environment/using-traditional-inuit-knowledge-and-western-science-to-study-arctic-marine-life**)
- Introduction to Scratch Series (**pinnguaq.com/learn/courses/introduction-to-scratch**)
- Why the Seal Hunting Controversy is Outdated (**youtu.be/we4URVISjEE**)
- Angry Inuk—Alethea Arnaquq-Baril joins a new tech-savvy generation of Inuit as they campaign to challenge long-established perceptions of seal hunting (**nfb.ca/film/angry_inuk**)
- Researcher Enooyaq Sudlovenick's Website (**enooyaqsudlovenick.com**)
- Using Twine to Understand our Responsibilities to Mother Earth: Environmental Protection from a Two-Eyed Seeing Perspective (**pinnguaq.com/learn/using-twine-to-understand-responsibilities**)
- Inuit Principles of Conservation: Inuit Values (Grades K–3) (**pinnguaq.com/learn/inuit-principles-of-conservation-inuit-values**)

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DATA

COURTESY OF TALIA METUQ

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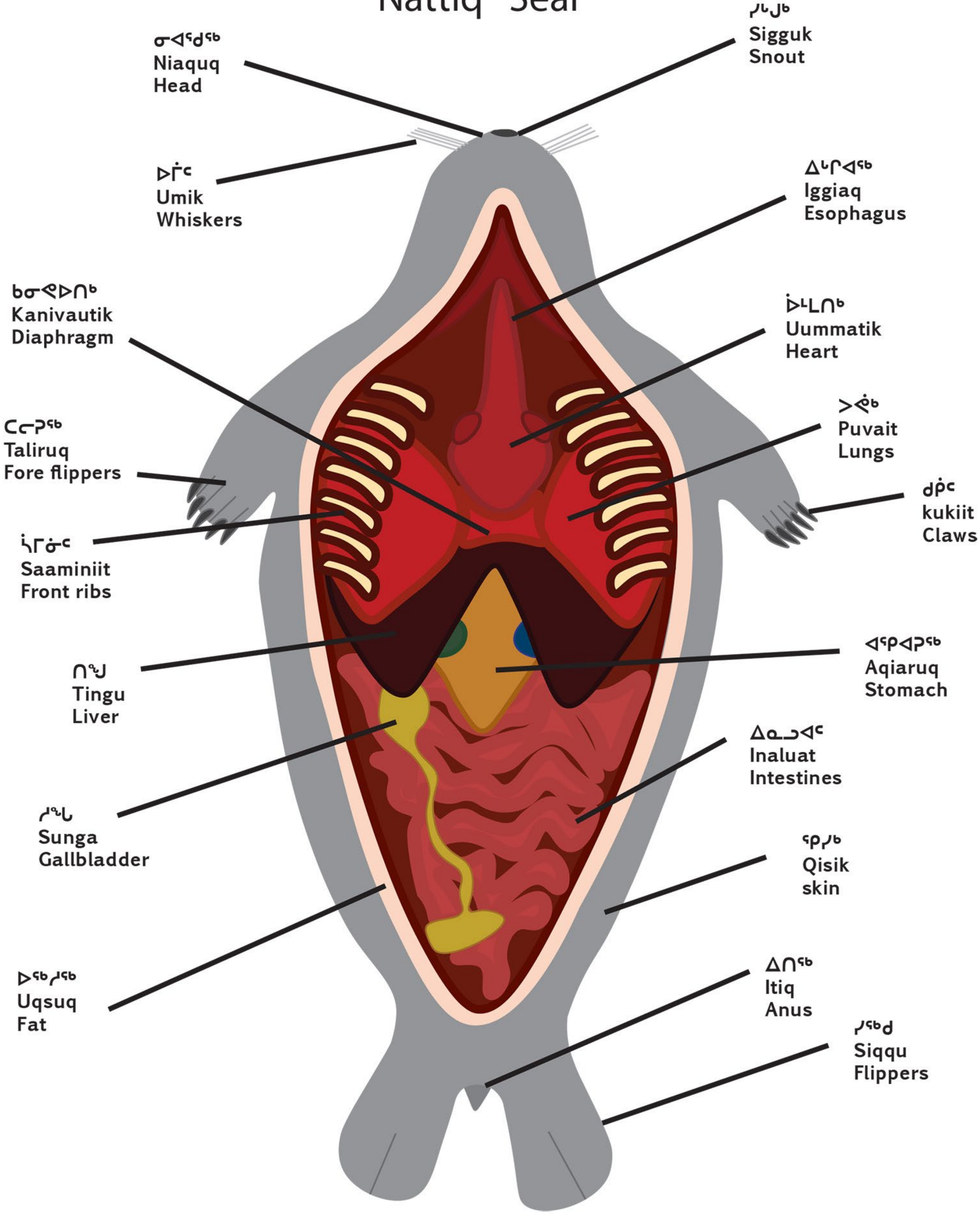
Nattiq Seal



Lesson 2

Grade Level: 3–6

The Environmental Impact of Climate Change

Overview

In this lesson, students expand on their learning from the Introduction to Nattiit (Ringed Seals) lesson (**pinnguaq.com/learn/introduction-to-nattiit**) and build their understanding of how nattiit are being affected by climate change and human activity. The students conduct a small research project on Arctic sea life and create a short podcast presentation for the class. The lesson concludes with an opportunity to explore solutions to rapid climate change and ocean conservation.

Learning Objectives

- How climate change is affecting marine mammals and their habitats
- The environmental impacts of climate change and human activity on nattiit and Inuit communities
- How to work in a team conducting research on marine mammals

Inuit Qaujimajatuqangit Principles

Note: *Sometimes known as IQ principles, or Inuit guiding principles. It should be noted that the spelling of Inuit terms often differs according to dialectal differences. The concepts remain shared despite spelling differences (Tagalik, Shirley.* ***pinnguaq.com/learn/inuit-principles-of-conservation-serving-others****).*

Qanuqtuurunnarniq (Being resourceful to solve problems): When hunting nattiit, Inuit hunters use a naluaqtuut (a sharp hunting tool) to get close to an individual nattiq. They place a feather over the nattiit's breathing holes in the ice to see when they are about to surface.

Avatimik Kamtsiarniq (Promoting environmental stewardship): Inuit use all the parts of the nattiit. Clothing is made out of the sealskin so nothing is wasted.

Piliriqatigiinniq/Ikajuqtigiinniq (Working together for a common cause): The important skills needed for harvesting and preparing the nattiq are taught to the younger generation through observation and practice.

Vocabulary

- **Climate Change** – The long-term change in the average weather patterns that have come to define Earth's local, regional, and global climates
- **Habitat** – A habitat includes physical factors, such as soil, moisture, light intensity, and temperature range
- **Environmental Impact** – Any change to the environment that occurs as a result of human activity, whether adverse or beneficial
- **Sila** – The air, the atmosphere, and the outdoor environment
- **Echolocation** – A technique used by many flying animals and marine life to navigate environments where there is insufficient visual information. For example, bats use echolocation to fly around in the dark and whales use it to find their way in the ocean, which may look the same in all directions. Wildlife that use echolocation make a sound and then listen to hear the sound reflected back to them
- **enviro:bit** – A chip that slots into a micro:bit to add sensors for air and weather, colour and light, and sound
- **Sound Sensor** – The enviro:bit has a built-in sound sensor, which allows it to measure the level of sound around it
- **Noise Pollution** – Sounds that are disruptive to the environment and human life
- **Sound** – Energy that travels in waves through air, water, or other substances, and that can be heard by humans

Materials

- Know-Want-Learn (KWL) and sensors worksheets (download at **pinnguaq.com/learn/environmental-impact-from-climate-change#materials**)
- A recording device, such as an iPad, laptop, or tape recorder

*For pointers on recording a podcast, check out Pinnguaq's course (****pinnguaq.com/learn/courses/planning-and-creating-a-podcast-using-audacity****).*

Introduction and Know-Want-Learn Exercise

After learning about the nattiq, students learn more about their environment, the ocean, and how climate change is affecting them. Have students complete the KWL exercise, jotting down what they know about climate change and what they want to know. Ask a few students to share what they wrote with the whole class.

Engage in class discussion by asking students to raise their hand if they have heard about climate change. Likely, most of the students have but they might not know of its implications for nattiit and Inuit.

Ask students to ask themselves:

- **K** – "What do I already **know** about climate change?"
- **W** – "What do I **want** to know about climate change?"
- **L** – "What have I **learned** about climate change?"

Students can wait to fill out and share the "L" (learn) part of the worksheet until later in the lesson.

Listening Activity

What Is Climate Change?

Climate change is happening all around us, all around the world. It is impacting Earth in various ways, but climate change is more than just an environmental issue; it is a human issue. Climate change looks different depending on where we are looking at it. In the Arctic, it looks like the premature melting of ice and contamination of the ocean, where marine mammals are affected. Because a large part of the diet of Inuit is marine mammals, such as nattiit, this contamination affects Inuit livelihood and food sources. Nattiit rely on their ice habitat for numerous reasons. Many of their activities are dictated by the timing of the formation and break-up of ice sheets. One of the most significant impacts of climate change on nattiit, and in turn Inuit, is the loss of Arctic sea ice.

The Ocean

Nattiit breeding is dependent on the availability of sufficient ice at the correct time of year in areas with sufficient food nearby.

As Arctic ice continues to melt earlier each year, more and more pups may be separated prematurely from their mothers, resulting in high pup mortality. Both ice and snow must be stable enough in the spring to complete the six-week period of lactation.

Spring rains or warm spring temperatures can cause the roofs of lairs to collapse, leaving nattiit unsheltered and exposed to predators. Insufficient snow at the beginning of the breeding season can have the same effect.

In some areas, nattiit are already showing relatively long-term declines in reproductive rates and pup survival. Kovacs and Lydersen report: "During 2006 and 2007, many of the fjords on the west coast of Svalbard did not freeze for the first time in recorded history. Nattiit reproduction was virtually non-existent in areas where many hundreds of pups are normally born. It is not known if the nattiit that normally pup in this region established themselves elsewhere early enough to set up territories and build lairs, etc., but it seems highly unlikely." (Reference from IUCN (**iucn.org**))

Environmental Impacts

Warmer ocean temperatures are likely to make conditions more favourable for parasites and pathogens that affect nattiit. The spread of these organisms is likely to be facilitated by the migration of nattiit as they are forced to seek more stable ice habitats. As Arctic conditions warm, a greatly increased presence of humans in previously inaccessible areas is anticipated. Activities such as shipping, agriculture, and oil exploration are predicted to disturb and further degrade habitats, and increased fishing may reduce food availability.

As sea ice recedes, more challenges emerge for Arctic marine species. Less ice means more open water, which allows for additional commercial activity.

Have students watch/listen to a portion (0:48–2:53) of a speech by Inuit activist Siila Watt-Cloutier (**youtu.be/GlSh4XeoLBA**) titled "Sheila Watt-Cloutier on Climate Change and Human Rights" to engage in discussion about climate change and its impact on Inuit.

After listening to the speech, ask:

1. What are students' reactions to Siila's speech?
2. How is climate change affecting nattiit?

Noise Pollution Sensor

Overview

Recall in the Introduction to Nattiit (Ringed Seals) lesson, we discussed IQ principles including Qanuqtururangniq, Pilimmaksarniq, and Avatimik Kamtsiarniq. All these IQ principles are important foundations for this activity. Discuss with your class what these IQ principles mean to them:

- Qanuqtururangniq (the ability to be resourceful and innovative to solve problems)
- Pilimmaksarniq (learning new skills through practice and observation)
- Avatimik Kamtsiarniq (respectfully caring for animals and the environment)

Activate Existing Knowledge

Lead a classroom discussion to uncover what students think might occur if more commercial activity begins in the Arctic Ocean. Seed the conversation by discussing what kind of industries might develop, such as:

- Increased shipping activity
- Increased oil and gas development

Some of the key outcomes of these industries include:

- Increased water pollution
- Increased incidences of oil spills
- Increased noise pollution
- Increased collision incidents with animals

Some secondary outcomes may include:

- More land development required to sustain these industries and their workers
- Increased pollution in the environment

Viewing Activity

Impacts of Noise Pollution in the Arctic

Animals, like us, make sounds to communicate with each other. However, this can be disrupted by loud noises that are not part of the natural environment. This is a problem known as noise pollution. Marine mammals are especially affected by noise pollution because noise is amplified in water and because many marine animals use sound (echolocation) to communicate, navigate the ocean, and find food.

Watch the video Less Noise, More Life (**youtu.be/QImSm0aK3lY**) presented by WWF Arctic Programme.

After the video concludes, lead a group discussion to consolidate learning. As a class, list some of the impacts noise pollution has on whale populations. Allow students to add any additional impacts they can think of even if they were not mentioned in the video. Some impacts include disruptions to:

- Mating habits
- Navigation (echolocation)
- Eating habits and food supply
- Abilities to locate pod members
- Migratory routes

Sensors Worksheet Activity

Have students complete the sensors worksheet. If learners struggle to think of examples of sensors in technology, provide additional examples, such as:

- Temperature sensors (some cars and vehicles have built-in temperature sensors that list the temperature both inside and outside the vehicle)
- Sound sensors (smart assistants like Siri, Alexa, or Google Home use sound sensor microphones to listen to users)
- Light sensors (many computer and TV screens now automatically adjust the brightness and colouration of their screens to respond dynamically to the light levels they sense in their environment)

Podcast Activity

This group activity requires additional class time to complete. The suggested time frame is over two weeks (one week to compile research and one more week to complete the podcast prep).

Climate change is an ever-changing condition, and because the issues and the impact of climate change are always evolving, students will become researchers themselves (kind of like Enooyaq, the PhD student who speaks in the podcast). In the research project, students choose another part of marine wildlife to research.

Examples include: aiviq (walrus), iqaluk (Arctic char), arviq (bowhead whale), tugaalik (narwhal), and qinalugaq (beluga whale).

Ask students what they need to do in order to be good researchers. Allow for responses as a whole class.

Answers might include:

- Conduct research and present information clearly and accurately for everyone to understand and access the research findings
- Consider the sources of the information you research

Explain that the class will break into groups of four or five to conduct research on the topic of rapid climate change and create a podcast report to share with the whole class.

In their groups, they will research and include a space on their handout for the following:

- What marine mammal will you research?
- Some facts about the marine mammal
- Its habitat (ocean and/or land)
- What does it eat?
- Is it a source of food?
- What are some of its adaptations to the environment? How do Inuit mimic or take from that innovation?
- How is climate change affecting the animals in their habitat?
- What is causing these changes?
- How are these changes affecting the many different habitats we share around the world with other animals and plants?

During the second week of the activity, help students record their podcasts on a recording device. For help in recording a podcast, check out Pinnguaq's course on podcasting (**pinnguaq.com/learn/courses/planning-and-creating-a-podcast-using-audacity**).

Activity Adaptation

As an adaptation to the podcast activity, students can make a poster with all the findings from their research project. The poster should answer all the same questions as the podcast but it should be written down and mounted on a poster board. The poster must include images of the marine mammal and be put together in a way that is pleasing to the eye. The poster should be presented to the class in the same way the podcast would be.

Conclusion

Ask students to complete the "L" part of their KWL worksheet by adding a few points about what they learned in this lesson.

Tech Extension Activity

Build a Sound Meter

It's time to measure noise levels out in the world!

Challenge learners to measure noise levels in their environment by disconnecting the micro:bit from the computer and plugging it into the battery pack. Learners may measure sounds around the school, or if possible, take the micro:bits home for a day and observe the noise of their daily life.

Spark interesting observations with the following questions:

- How noisy is your environment?
- Where was the loudest sound you observed and what caused it?
- Where was the quietest sound you observed and what caused it?
- Did the time of day affect the amount of noise?
- Did the weather affect the amount of noise?

For step-by-step instructions on how to build a sound meter using a micro:bit and the MakeCode editor, check out Pinnguaq's website (**pinnguaq.com/learn/environmental-impact-from-climate-change**).

IMPORTANT: micro:bits are not waterproof, so advise learners not to attempt to measure noise levels directly in water.

Resources

- Facts About Seals (**worldwildlife.org/species/seals**)
- National Geographic: Noise Pollution (**nationalgeographic.org/encyclopedia/noise-pollution**)
- Speech by Siila Watt-Cloutier (**youtu.be/GlSh4XeoLBA**)
- Definition of Sound (**collinsdictionary.com/dictionary/english/sound**)
- Researcher Enooyaq Sudlovenick (**macleans.ca/society/environment/using-traditional-inuit-knowledge-and-western-science-to-study-arctic-marine-life**)

Resources for Group Activity

- Canada's Arctic Marine Atlas (**oceansnorth.org/en/canada-arctic-marine-atlas**)
- Common Fishes of Nunavut (**inhabitmedia.com/2018/11/01/common-fishes-of-nunavut**)
- Beluga (**theglobaleducationproject.org/climate-change/animals/beluga**)
- All about Orcas (**inhabiteducationbooks.com/collections/animals-nature/products/all-about-orcas**)
- Animals that Live in Arctic Waters (**inhabiteducationbooks.com/collections/animals-nature/products/animals-that-live-in-arctic-waters**)
- What Arctic Animals Eat (**inhabiteducationbooks.com/collections/animals-nature/products/what-arctic-animals-eat**)
- Indigenous People's Atlas of Canada (**indigenouspeoplesatlasofcanada.ca/article/wildlife**)
- Cultural Significance of Polar Bears (**polarbearscanada.ca/en/polar-bears-canada/cultural-significance**)

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Lesson 3

Grade Level: 7–8

Water Monitoring Project

Overview

In this lesson, students continue learning how to use the micro:bit in a hands-on lesson in which they develop and test a water quality monitoring system.

Materials

- Scientific observation worksheet (download at **pinnguaq.com/learn/water-monitoring-project#materials**)
- micro:bit
- Battery pack
- AAA batteries (2×)
- Edge connector breakout board
- Turbidity sensor
- Male-female jumper cables

Part 1 – Introduction

Prepare three glasses of water as follows:

- One glass of clean drinking water
- One glass of ocean water if accessible—otherwise, dissolve salt in the water
- One glass of dirty water. Mix in dirt or any other contaminant

Complete the scientific observation worksheet, available for download at **pinnguaq.com/learn/water-monitoring-project#materials**.

Turbidity

Turbidity measures the transparency of water, which can change based on how many particles are suspended in it. When contaminants are present in water, it can become cloudy or murky, and the turbidity level increases. This makes turbidity a great initial measurement to track water quality over time. In this project, we use a turbidity sensor to monitor water quality.

Part 2 – Make Connections

Broken Messages Activity

It is important that our computers be able to communicate properly with the micro:bits and the attached sensors because we are using these wires to send and receive specific information. If we break one of these connections, the messages we send may not get through.

To understand how important it is that the wires are connected precisely, facilitate a game of broken telephone:

1. Gather students into a circle (you may wish to split learners into smaller groups—minimum of three students per group).
2. The person starting the game thinks of a word or phrase and whispers it into the next player's ear. The word/phrase can only be said once—no repeats!
3. The person who listened to the word/phrase attempts to repeat it correctly into the ear of the player beside them. Repeat until the last participant is reached.
4. The last participant repeats the phrase or word aloud.
5. Allow a moment for learners to react and laugh if the message has been changed or "broken".
6. The player who started announces the correct word or phrase.
7. Players take turns as the starter.

Variation

(for students with a hearing impairment):

- Alternate saying and drawing the phrase
- Cover ears and read lips

After the game, facilitate a discussion with learners about the challenges they encountered while trying to communicate this way. On a blackboard or whiteboard, list what good communication strategies are.

Tech Activity

Create a Water Quality Monitor

In this activity, students learn how to create a water quality monitor. A step-by-step guide is available at **pinnguaq.com/learn/water-monitoring-project**.

Conclusion

Students should ask what it means to love and cherish water. Set aside time for students to research ways communities work towards better ocean conservation practices. The following is a list of organizations that advocate in different ways for ocean conservation; select one of the organizations and research more about their work.

Organizations

- Ocean School (**oceanschool.nfb.ca**)
- Ocean Wise (**ocean.org**)
- Clear Lab (**civiclaboratory.nl**)
- Ocean North (**oceansnorth.org**)
- World Wildlife Federation (**wwf.ca**)

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Lesson 4

Grade Level: 9

Innovative Climate Change Solutions

Overview

In this lesson, students learn about how humanity has taken inspiration from nature when considering solutions to complex problems. Students will see examples of how micro:bits can be used to innovate and solve problems. The lesson concludes with an overview of design thinking and iterative design. Learners participate in a design challenge to develop a solution to one of the ocean conservation issues in the previous lesson.

Vocabulary

- **Speculative Design** – A design method addressing big societal problems and looking toward the future—and creating products and services for those scenarios (Ho Tran, 2019)
- **Iterative Design** – A form of design in which students continually work and improve upon their design, with the goal of continual improvement (rather than building something once and never touching it again) (Engineless, 2021)

Sources

- Ho Tran, T. (2019, April 8). Speculative Designs: 3 examples of design fiction. Invision. **invisionapp.com/inside-design/speculative-design**
- Macy, J., & Johnstone, C. (2018, April 30). The Great Turning. Gaia Education. **https://gaiaeducation.medium.com/the-great-turning-977cbc7df74**
- Schweitzer, K. (2019, November 12). Curriculum Design: Definition, Purpose and Types. ThoughtCo. **thoughtco.com/curriculum-design-definition-4154176**

Materials

My Better World and facilitator's guide worksheets (download at **pinnguaq.com/learn/innovative-climate-change-solutions#materials**).

Viewing Activity

Introduce the UN's Global Sustainable Goals

Watch the following video about the UN's Global Sustainable Goals.

The World's Largest Lesson | Global Goals (**youtu.be/cBxN9E5f7pc**)

After viewing the video, complete the My Better World worksheet. As learners complete the worksheet, have them brainstorm what their interpretation of what a better world would look like. They can include their thoughts in the bubbles or categorize them.

Some helpful prompts might include:

- Where would you live?
- What would you do as a job?
- Who would you be with?
- Would you have any goals for the world around you or your community?
- How would you feel?

After completing the worksheet, discuss why it is important to develop goals that everyone on the planet can work toward. As the people do in the video, brainstorm what the class would include in their sustainable goals.

Bonus: Visit the UN website (**sdgs.un.org/goals**) to explore the UN's goals together. Pay particular attention to **#13 Climate Action** and **#14 Life Below Water**. Compare and contrast with the list you developed as a class.

Extra Bonus: Some free resource tools you might find useful to digitally collaborate with are:

- Jamboard (**jamboard.google.com**)
- Popplet (**popplet.com**)
- MindMup (**mindmup.com**)

Viewing Activity

Design Redefined

The *Design Redefined* video series is an engaging resource for learning about biomimicry (when nature inspires human-made technologies and innovations). Each video explores a different design found in nature and provides examples of how scientists around the world seek to replicate that engineering in modern innovations. Most videos also include a visual explanation of the mechanics behind each design element to show how modern technology can learn from nature.

Introduction

Part 1 explores what viewers can expect from the *Design Redefined* series, what biomimicry is, and inspiration found in nature for modern technology design.

Design Redefined Introduction (**youtu.be/RdTjt7g-GE0**)

Humpback Whales

Part 2 explores the humpback whale's flipper, which is the secret behind its graceful and agile swimming. Viewers also learn how scientists find inspiration in the flipper for designs of airplanes, underwater vehicles, and wind turbines.

Design Redefined Episode 2: Humpback Whales (**youtu.be/fUoBpaZjwGI**)

Seahorse Tails

Part 3 explores the seahorse tail and how, despite being unusual, the tail provides greater flexibility when moving. Viewers learn how scientists can replicate this design in robotic arms to help with everything from underwater exploration to search-and-rescue operations.

Design Redefined Episode 3: Seahorse Tails (**youtu.be/TIJjFTIjOgA**)

Design Discussion

As a class or in small groups, have learners brainstorm technologies that might be inspired by innovations in nature.

Design Thinking Challenge Activity

In this activity, learners become innovators to protect the ocean and explore design strategies using an iterative design approach. A step-by-step guide for this activity can be found at **pinnguaq.com/learn/innovative-climate-change-solutions**.

Facilitator's Guide

Design Thinking Challenge Activity

In this activity, students explore design strategies and the value of connecting to end users—the people the design is intended for—

during the process to help validate design decisions. Students also learn the value of an iterative design approach. This activity can be completed over two or three periods—the first period to gather research on their assigned marine species and the second (and third) period(s) to design potential solutions.

Set Up the Activity

- Learners complete most steps individually but will need to work with partners for some elements. Set up the learning space to accommodate this
- For the working environment, consider ways to promote creative learning spaces, such as playing upbeat music or rearranging the classroom
- Display a widely visible timer that lets learners know how much time they have left during each step

Step 1 → Select a Marine Species to Research
Consider the following questions:

- What marine mammal will you research?
- Some facts about the marine mammal
- Its habitat (ocean and/or land?)
- What does it eat?
- Is it a source of food?
- What are some of its adaptations to the environment? How do Inuit mimic or take from that innovation?
- How is climate change affecting the animals in their habitat?
- What's causing these changes?
- How are these changes affecting the many different habitats we share around the world with other animals and plants?

Learners can prepare notes that they can share with a partner in the exercise in the next step.

Step 2 → Gather Information from Partners
Split learners into pairs. Ideally, each partner in a pair has researched a different marine species.

The challenge is for each partner to gather as much information as they can about the needs of their partner's marine animal. Partner A has four minutes to interview Partner B, then switch.

To begin, ask each set of partners to tell each other all about the marine species they researched. Questions they may ask each other might include:

- What habitat does it live in?
- How do humans interact with it?
- What challenges does this animal face?

Make notes as you speak.

Step 3 → Make Discoveries
Outline two or three key takeaways from your conversation with your partner. Write down one or two issues they identified that their marine species encounters. Be as descriptive as possible!

For an example of a notes outline, see below:

Partner A:
Marine Animal:

Takeaways

1.

2.

3.

Issues

→

→

Partner B:
Marine Animal:

Takeaways

1.

2.

3.

Issues

→

→

Step 4 → Synthesize Information
In this step, challenge learners to synthesize all the information they have gathered so far and distill it into a problem statement. They should focus on a single problem identified in the previous step.

Learners are gathering information and encouraged to use rich descriptive language to identify the problem. Then learners try to identify what the world would look like if this problem were solved. Lead this section for learners by asking: **"What in the world around this animal would need to change in order for the problem you have identified to be solved?"**

For example: "Beluga whales are facing interruption to their communication, feeding, and migration as a result of noise pollution. They would need quiet oceans in order to maintain communication, feeding, and migration."

Step 4 → Summarize
Using what has been learned and summarized from their conversations, learners should fill in the blanks in the following statement to identify their problem statement.

For a conversation outline example, see below:

____
(species name)

are facing

____
(challenge)

caused by

______________________________ .
(describe the cause of the challenge)

They need

____
(describe their ideal world/environment)

in order to

______________________________ ,
(outcome)

which helps support healthy oceans!

For Example: Ringed seals are facing contamination in their food supply caused by ocean pollution. They need clean oceans in order to maintain a good diet without the risk of contaminants, which helps support healthy oceans!

Step 5 → Explore the Future

In this step, try to encourage learners to imagine themselves standing in a place and time in the future. This step is meant to be purely imaginative. There are no constraints on the futures we are designing. If there is new technology in this future, it doesn't have to be anything that is possible or even plausible to make today.

Motivate learners with the following details:

- Any technology that exists in the future you propose does not have to be possible in today's world
- Technology may have changed, but laws, policy, and human activity may have changed too!
- There are no wrong answers when we are world-building

If learners struggle, seed their imagination by asking them to describe what can be detected by their five senses (sight, sound, smell, touch, and taste) in the future.

For example, if learners imagine a future in which Arctic waters are clean enough for ringed seals to survive, that might mean that:

- The Arctic Ocean is full of marine animals; all animal populations now in decline have recovered
- Solar and wind power are so advanced that there is no more oil or gas being extracted
- Production of plastics has been banned and we have capacity to produce plant-based bioplastics to replace ALL plastics

Create an environment that might help promote creativity during this process. For example, consider playing background music as students sit with their thoughts. Ask students to refrain from talking while everyone is left with their thoughts to consider the possibilities for the future.

Step 6 → Imagine a Future World

Have learners read over their problem statement again. Now consider a future in which the problem has been solved and their solution has occurred. What does it look like? What is different from today? How much time has passed? Have learners write or doodle their responses. Remind learners that their ideas can be as far-fetched as they would like. Remind learners to ground themselves in the future world they developed in the previous step. This can be done by again focusing on the five senses and taking note of what they observe.

"Remind yourself that in this world the problem you identified has been solved. What kind of technologies could have helped get the world to this state?"

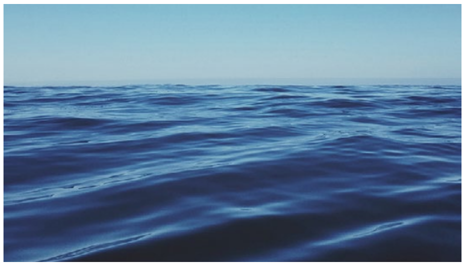
To continue with the ringed seals example:

- New bioplastics exist that are fully biodegradable
- Saltwater batteries power vehicles
- Autonomous robots swim through the ocean to collect plastic trash from the past
- We have developed technology that can quickly convert all types of garbage into harmless compost

Step 7 → Discover Future Artifacts

Now that you have transported yourself to the future, what technologies exist? How has human activity changed? Use the boxes below to brainstorm four ideas in words or images.

Step 8 → Social Media Post Exercise
How did your imaginary innovation change the world for the better? We can also consider this exercise to be comparable to a social media post. What would the headline be? What would an accompanying image show? What details would the article reveal about the invention or the world? Focus on one of the technologies you discovered in the future. Think about the day that the problem you identified has been solved using that technology. Draw a picture for your post and write a caption that explains what made it all possible.



Caption example: The oceans are now completely plastic-free! The invention of ocean clean-up robots has allowed us to remove all plastic waste from the oceans. As a result, species affected by ocean contamination—such as ringed seals—are thriving again.

Step 9 → Conclusion
Congratulate learners at the end of this step! They have successfully visited the future and brought back some important knowledge to us in the present! Lead a debrief with the group: **Now we know what an ideal future looks like and the practices and technologies that exist there. How can we use that information in the present?**

Guide learners to the understanding that having clear, positive ideas about the future allows people in the present to determine what steps need to be taken to reach that future. For example, if you have identified that ocean clean-up robots would require clean energy power sources, we might imagine that they would be powered by saltwater batteries. We can now continue to work backwards from here. What innovations/inventions would be required to develop saltwater batteries?

For example: Protective coatings for metal wires so they do not become corroded by saltwater OR replacements for metal wires.

If we continue working through this exercise, eventually we arrive at an innovation that is not far out of reach in the present day. In the example above, we identified that protective coatings for wires or waterproof wire materials would be needed. This is technology that is currently available and this exercise has helped show that working on protective metal coatings could lead to much larger future innovations.

You may choose to work one example backwards with your class or have all the students attempt it, or you may leave the exercise here. What is important to realize is that from these speculative futures, it is possible to reverse engineer strategies and innovations that can be developed and enacted in the present moment.

Speculative design is an important problem-solving approach because it frees designers from present-day constraints and allows them to imagine any and all possible futures. This creates the opportunity for extraordinary optimism, possibility, and "active hope" (Macy & Johnstone, 2018).

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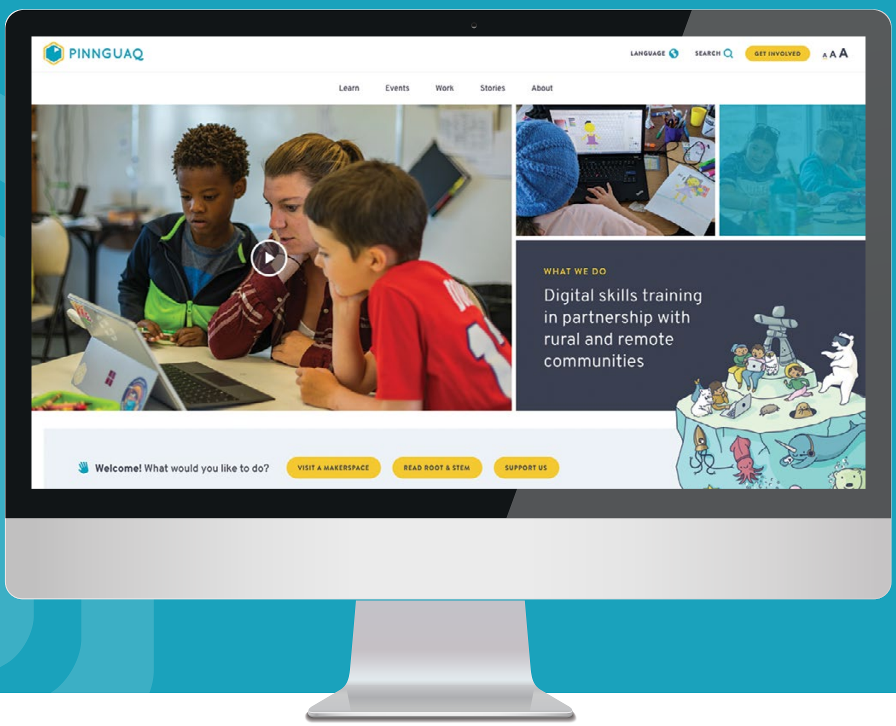

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